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A COMPARISON AND VALIDATION OF TWO SURFACE SHIP READINESS MODELS

by

Blaine S. Pennypacker

September 1994

Thesis Advisor: So Young Sohn

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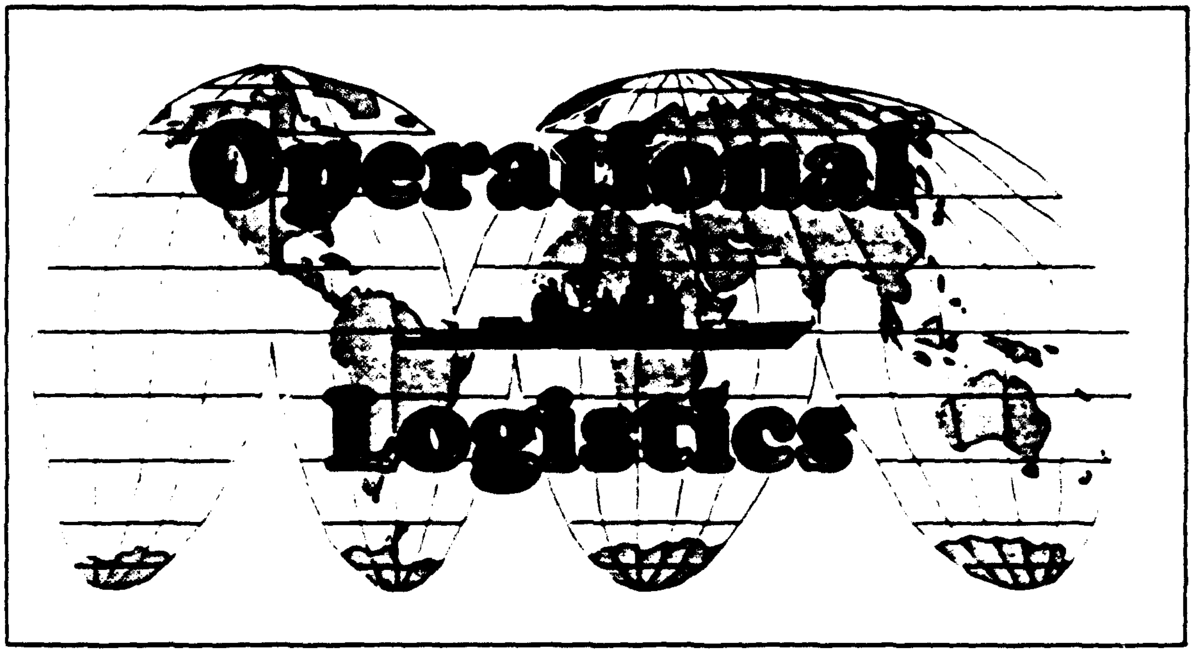
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A COMPARISON AND VALIDATION OF TWO SURFACE SHIP READINESS MODELS

Blaine S. Pennypacker
Lieutenant, United States Navy
B.S., United States Naval Academy, 1988

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Author: ______________________
Blaine S. Pennypacker

Approved by: ______________________
So Young Sohn, Thesis Advisor

____
LCDR Kevin Becker, USN, Second Reader

____
Peter Purdue, Chairman
Department of Operations Research

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Two models are used by the U.S. Navy to predict surface ship readiness: the Surface Ship Resources to Material Readiness Model (SRM) and the Surface Ship Inventory to Material Readiness Model (SIM). This thesis examines both models, in order to validate the model fit and to determine whether the two models predict significantly different levels of readiness for a given data set using both cross validation and jackknife procedures. Examination of the models reveals that there are numerous insignificant predictor variables in the models. Normality assumptions made on the non-linear regression are not proper. Additionally, the performance of both the SRM and the SIM at the ship level is poor. However, once aggregated to the fleet level, prediction performance improves drastically. Analysis of the jackknife confidence intervals indicates that the SRM and SIM predict significantly different levels of readiness. While the SIM performs slightly better than the SRM, one has to consider the marginal cost associated with the more complex SIM for model selection. Finally, use of reduced models and model modifications such as use of Poisson regression are recommended.

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The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. The reader is cautioned that computer programs developed in this research may not have been exercised for all cases of interest. While effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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EXECUTIVE SUMMARY

Since Fiscal Year 1979, Congress has required the Department of Defense (DOD) to estimate the effects of requested resources on combat readiness. This problem, typically referred to as the "resources to readiness problem," is of current special interest to the Navy. In order to describe the time-based readiness of a ship in material terms, the measurement "Percent Operating Time Free" (POTF) of Casualty Reports (CASREPs) has been adopted by OPNAV N81.

Two regression models, the Surface Ship Resources to Material Readiness Model (SRM) and the Surface Ship Inventory to Material Readiness Model (SIM), were developed to predict surface ship POTF by Mathtech Corporation under contracts for OPNAV N81 and NAVSUP. Both SRM and SIM models employ a nonlinear regression analysis. Many inputs are the same and both models predict readiness in terms of POTF of C3/C4 CASREPs. There are concerns at N81, NAVSUP, and Mathtech that the two models may predict significantly different levels of readiness despite their similar approaches. Since each model is used by the respective organizations for resource allocation budget requests, it is important that their readiness predictions are consistent. This thesis re-examines both models to validate model fit and to determine whether the two models predict significantly different levels of readiness using the jackknife procedure.

Examination of the models reveals that there are numerous insignificant predictor variables in the models. The prediction performance of both the SRM and the SIM at the ship level is poor, however, once aggregated to the fleet level, performance improves drastically. The SIM turns out to perform slightly better than the SRM in terms of the mean relative error (MRE) criterion.

To investigate the predictive power of the models, the cross validation method is used by partitioning the data set into two subsets: the construction set consisting of observations from 1982-1990 is used to fit the regression models, and the validation set consisting of observations from 1991 and 1992 is used to predict the dependent variables. Cross validation results indicate that the SRM performs better at predicting POTF in 1991, and the SIM performs better in 1992.

The jackknife procedure is applied by obtaining 120 predictions of fleet level POTF, each based on a reduced data set. Using these predictions, confidence intervals for annual and overall fleet level POTF predictions are produced. Analysis of the jackknife confidence intervals indicates that the SRM and SIM predict significantly different levels of readiness. Additionally, since the many of the SIM confidence intervals either contain the actual fleet level POTF values or are closer to them than the SRM, the SIM appears to perform slightly better than the SRM.

Several conclusions are reached. The SIM performed slightly better at predicting readiness than the SRM, however, this marginal gain may not offset the marginal cost of the more complex SIM. Both models can be simplified by eliminating insignificant predictor variables. Remodeling of the SRM and SIM at the ship level using a Poisson regression is strongly recommended.

I. INTRODUCTION

A. BACKGROUND

Since Fiscal Year 1979, Congress has required the Department of Defense (DOD) to estimate the effects of requested resources on combat readiness. This problem, typically referred to as the "resources to readiness problem," is of current special interest. The Navy and the DOD are concerned with the long-term effects of force and budget downsizing on overall surface ship readiness. Defense dollars must be allocated in such a way as to "rightsize" our forces without sacrificing the readiness of those remaining. The high visibility of force readiness both in Congress, the press, and the military establishment is a result of experience from cutbacks made during the post-Vietnam era and the "hollow force" which resulted [Ref. 1].

1. Readiness

The term "readiness" is open to various interpretations and definitions. This is due to the many ways in which readiness may be defined. For example, one possible definition concerns the ability of personnel to operate the highly complex weapons systems on navy ships. A second may concern the number of surface ships operationally available to a commander at a given time. Yet another may concern the ability of a specified quantity of ships to successfully conduct a particular mission. The definitions chosen to describe the level of readiness of the Surface Fleet by the Office of the Chief of Naval Operations Program Resource Appraisal Division (OPNAV N81) and Naval Supply Systems Command (NAVSUP) are based on a ship's material readiness.

When a piece of equipment is out of commission on a Navy ship, a Casualty Report (CASREP) is submitted. The CASREP alerts various technical assistance and supply facilities that the ship requires support. There are three levels of impairment for operational units, namely CASREP categories C2 to C4. A C2 CASREP is submitted

when the inoperable equipment causes a major degradation or total loss of a ship's secondary mission area. A C3 CASREP is submitted when the inoperable equipment causes a major degradation but not total loss of a ship's primary mission area. A C4 CASREP is submitted when the inoperable equipment causes a total loss of a ship's primary mission area. [Ref. 2]

In order to describe the time-based readiness of a ship in material terms, the measurement "Percent Operating Time Free" (POTF) of C3 and C4 CASREPs has been adopted by OPNAV N81. This measure was chosen because it can be readily calculated and is generally accepted as a valid indicator of material readiness. The primary definition of material readiness used by NAVSUP is based on operational availability (Ao). Ao is defined as the "...probability that a system is up and ready to perform as intended" [Ref. 3]. Recently however, NAVSUP has shown an interest in using POTF and has adopted it as a supplementary measurement of readiness.

2. Model History

In order to accomplish the task of obtaining acceptable predictions for material readiness, several models have been developed for the Navy. Two statistical models (Appendices A and B) for predicting surface ship POTF were provided by Mathtech Corporation under contracts for OPNAV N81 and NAVSUP: the Surface Ship Resources to Material Readiness Model (SRM) and the Surface Ship Inventory to Material Readiness Model (SIM). The models are used to justify requests for resources in terms of the potential benefits accruing from improved material readiness. Additionally, the models are used to examine the potential effects that funding cuts among various managed resources would have on ship readiness. This is accomplished by entering the values of the managed resources into the models as predictor variables. Both models employ non-linear regression analysis and predict surface ship material

readiness based on a variety of predictor variables which are determined to have significant impact on POTF. In general, the resources to readiness problem is more complicated for ships than for other weapon systems. Several factors contribute to this, which include evolving system configurations and time lags associated with the effects of resource expenditures [Ref. 4].

a. SRM History

Created in 1986, the SRM is used to predict readiness in terms of POTF based on a variety of factors. The initial model has undergone several major changes as well as some minor upgrades, advancing from an original LOTUS 1-2-3 spreadsheet to a proprietary software application. POTF predictions are based on a number of predictor variables, including among others, ship class, funding for spare parts, number of annual steaming days, and maintenance (depot, intermediate and organizational level).

b. SIM History

The SIM was initiated in 1992 after the Fleet Support Quality Management Board (QMB) conducted a review called the Inventory Reduction Study. The study used a modification of the SRM to forecast the effect of several inventory reduction initiatives on surface ship readiness. Although the form of the SIM is identical to the SRM, the SIM differs from the SRM in two primary ways. First, it eliminates several of the SRM predictor variables and secondly, it adds two inventory related predictor variables to the SRM: average customer wait time (ACWT) and ready for issue (RFI) inventory. Forecasts for each of these variables are obtained through the use of two separate regression models. The SIM, also produced by Mathtech, is currently being revised, however, the revision will likely incorporate most of the current model.

B. PROBLEM DESCRIPTION

In summary, both SRM and SIM models employ similar statistical methods. Many inputs are the same and both predict readiness in terms of POTF of C3/C4 CASREPs. There are concerns at N81, NAVSUP, and Mathtech that the two models are predicting two significantly different levels of readiness despite their similar approaches. Since each model is used by the respective organizations for resource allocation budget requests, it is important that their readiness predictions are consistent. The main purpose of this thesis is to compare the SIM to the SRM in order to determine whether the SIM tends to predict a significantly different level of readiness from the SRM. Such an analysis provides the Navy with the quantitative rationale for whether the SIM is worth the additional modeling effort and expense as compared to the simpler SRM. Additionally, this thesis provides a validation of the SRM and SIM which provides a means for evaluating the effectiveness of the predictions obtained by both models.

II. DESCRIPTION OF MODELS

This section describes the details of the SRM and SIM and how each model is used to predict values of POTF of C3/C4 CASREPs.

A. SRM

1. Dependent Variables

For prediction purposes, the SRM divides ships into three general shipboard categories: Hull and Mechanical (HULL); Command, Control, and Communications (COMM); and Weapons Systems (WEAP). The SRM predicts the expected number of new CASREPs produced by every ship in the Navy per year in each of the three categories. These dependent variables are called New CASREPs ($NEWCAS_{HULL}$, $NEWCAS_{COMM}$, and $NEWCAS_{WEAP}$, respectively). The model also predicts the mean amount of time, by year, that each ship in the Navy takes to correct a CASREP in each of the three shipboard categories. These dependent variables are called Mean Time To Correct ($MTTC_{HULL}$, $MTTC_{COMM}$, and $MTTC_{WEAP}$, respectively). Thus, the SRM consists of six regression submodels, one for each of three MTTC dependent variables and three NEWCAS dependent variables. The expected number of days per year that a ship will not be materially capable (DOWNTIME) is computed for each shipboard system category by taking the product of MTTC and NEWCAS:

$$DOWNTIME_{HULL} = MTTC_{HULL} \times NEWCAS_{HULL} \quad (1)$$

$$DOWNTIME_{COMM} = MTTC_{COMM} \times NEWCAS_{COMM} \quad (2)$$

$$DOWNTIME_{WEAP} = MTTC_{WEAP} \times NEWCAS_{WEAP} \quad (3)$$

The three DOWNTIME variables when added together estimate the cumulative time each ship can be expected to be incapable of fully performing all primary mission areas in a given year:

$$DOWNTIME = DOWNTIME_{HULL} + DOWNTIME_{COMM} + DOWNTIME_{WEAP} \quad (4)$$

To obtain the annual POTF of C3/C4 CASREPs of each ship, the following equation is used based on queuing theory:

$$POTF = e^{(-DOWNTIME*K)} \quad (5)$$

This equation was chosen by Mathtech based on the assumption that CASREPs arrive according to a Poisson process where the random time between both the "arrivals" (when a CASREP is submitted) and "departures" (when a CASREP is cleared) of CASREPs follows an exponential probability distribution. The justification for this assumption is given by Mathtech [Ref. 4, pp. A-1-A-8]. Finally, in order to obtain fleet-wide average annual values of POTF, a weighted average of the POTF of each ship is computed as follows:

$$POTF_{FLEET} = \sum_{i=1}^{n} \left\{ \frac{(Annual\ Operating\ Days\ for\ Ship\ i) \times (POTF_i)}{Total\ Annual\ Fleet\ Operating\ Days} \right\} \quad (6)$$

$$i = Ship, \quad n = Total\ number\ of\ ships\ in\ the\ fleet$$

The weight factors account for the number of operating days the ship had compared to the rest of the fleet. The overall value of POTF is used in the budget negotiation process.

2. Predictor Variables

To obtain expected values for the MTTC and NEWCAS submodels, non-linear regression analyses are performed in accordance with the following model specification:

$$E(MTTC_i) = \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p) \quad (7)$$

$$E(NEWCAS_i) = \exp(\alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \ldots + \alpha_p x_p) \quad (8)$$

$$i = HULL,\ COMM,\ WEAP \quad x_1 \ldots x_p \text{ are predictor variables}$$

The predictor variables used in the six SRM regression submodels include a number of readiness related effects. These are ship class, operations and sustainability (O&S) resources (spares, maintenance labor, outfitting, and rework), fleet maintenance

policy (improved shipboard spares allowances, spacing of overhaul availabilities, and duration of overhaul availabilities), force structure (procurement policy and retirements), fleet operating tempo (optempo), and crew quality (proportion of E-7 through E-9 rates embarked). The data set received from Mathtech for the SRM model consists of 4127 observations of 308 variables from the years 1980-1992. Of these, only 69 predictor variables and 3826 observations from the years 1981-1992 were used by Mathtech to fit the model. Sixty of the predictor variables are dummy variables used to identify classes of ships and nine are budget, personnel, and supply-related. The ship classes represented in the data set are displayed in Table 1.

Type	Class	Type	Class	Type	Class
AD	Samuel Gompers	AS	Simon Lake*	CVN	Enterprise
AE	Kilauea*	ASR	Chanticleer		Nimitz
	Suribachi*		Pigeon*	DD	Hull
	Nitro*	ATF	Cherokee		Spruance
AFS	Mars*	ATS	Edenton	DDG	Charles F. Adams
AGF	Flagship (Conv LPD)	AVM	Great Republic		Coontz
AO	Cimarron*	BB	Iowa*		Kidd
	Jumbo	CG	Belknap	FF	Bronstein
AOE	Sacramento		Leahy		Garcia
AOR	Wichita		Ticonderoga		Knox
ARS	Diver	CGN	Bainbridge	FFG	Brooke
	Safeguard*		California		Oliver H. Perry
AR	Vulcan*		Long Beach	LCC	Blue Ridge
AS	Emory S. Land*		Truxton	LHA	Tarawa
	Fulton	CV	Forrestal	LKA	Charleston
	Hunley*		J. F. Kennedy	LPD	Austin
	L. Y. Spear*		Kitty Hawk		Raleigh
LPH	Iwo Jima	LSD	Whidbey Island	MSO	Aggressive
LSD	Anchorage	LST	Newport	PHM	Pegasus
	Thomaston	MCM	Avenger		

Table 1. Ship Classes Included in the SRM.

* See p.19.

Each of the six dependent variables use a different number and combination of the ship class dummy variables in their submodels. The remaining nine predictor variables are:

1. The percentage of personnel in the top three enlisted paygrades on the ship (TOP3PR).

2. Organizational and Intermediate level parts funding (APARTPS).

3. Organizational and Intermediate level labor funding (ALABPS).

4. Time in days since the ship's last depot-level repair period (TSLDPE).

5. Length in days of the ship's last depot level repair period (LGLDPE).

6. Depot-level maintenance money spent on the ship in the previous year (DEPOTM1).

7. Binary for whether or not the ship implemented the Modified Fleet Logistics Support Program Consolidated Shipboard Allowance system (MOD).

8. The number of hours the ship was underway during each year (HRSUWM1).

9. Cost of overhaul, rework or repair of major ordnance equipment (ORDREW).

Only three of the above variables, TOP3PR, APARTPS, and ALABPS, are used in the MTTC submodels. All of the above nine variables are used in the NEWCAS submodels. The relationships of the predictor variables to each SRM submodel are shown in Table 2. Figure 1 displays a summary of the model relationships for the SRM.

MTTCH	*MTTCC*	*MTTCW*	*NEWHULL*	*NEWCOMM*	*NEWWEAP*
TOP3PR*	TOP3PR	TOP3PR*	TOP3PR	TOP3PR	TOP3PR
APARTPS	APARTPS	APARTPS	APARTPS	APARTPS	APARTPS
ALABPS	ALABPS	ALABPS	ALABPS*	ALABPS	ALABPS
			TSLDPE	TSLDPE*	TSLDPE
			LGLDPE*	LGLDPE*	LGLDPE*
			DEPOTM1*	DEPOTM1*	DEPOTM1*
			MOD*	MOD*	MOD
			HRSUWM1*	HRSUWM1*	HRSUWM1
			ORDREW	ORDREW*	ORDREW*

Table 2. SRM Independent Variables (Non-Ship-Class).

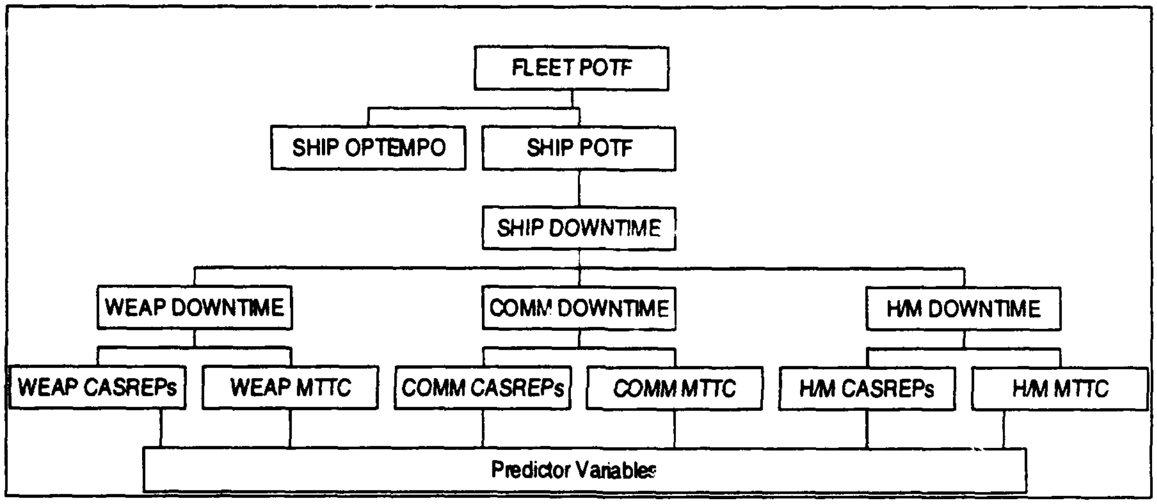

Figure 1. Model Overview.

B. SIM

1. Dependent Variables

The dependent variables for the SIM are exactly the same as in the SRM. The same categories, submodels, and model relationships also are identical to the SRM. Therefore, Figure 1 also applies to the SIM.

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* See p.19.

2. Predictor Variables

The predictor variables used in the six SIM regression submodels are similar to those in the SRM. While some predictor variables used in the SRM are not employed in the SIM, the SIM includes two additional predictor variables, namely the supply and logistics related effects of Average Customer Wait Time (ACWT) and Ready For Issue (RFI) parts inventory. ACWT is the average time a ship must wait between the time of any mechanical failure and the receipt of the required repair parts. ACWT includes all CASREPs and all mechanical failures experienced by the surface fleet [Ref. 5] and was added only to the NEWCAS regression model equations. RFI parts inventories include those parts that are immediately available for installation. The RFI variable was added only to the MTTC regression model equations.[1] The data set provided by Mathtech for the SIM had the identical variables as the SRM data set, but did not include variables for 1981 and 1992. It was decided to use the same data set that was applied to the SRM analysis for consistency. Since ACWT and RFI were not supplied for 1981, only observations from 1982-1992 were used. Also, RFI was not supplied for 1992, so a simple linear regression was performed on the RFI data to obtain a prediction for 1992 RFI[2]. The data used for SIM analysis consist of 3504 observations. Fifty-four of the predictor variables are dummy variables used to identify classes of ships and 11 are budget, personnel, and supply-related. The ship classes represented in the data used for the SIM are displayed in Table 3.

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[1] The ACWT and RFI predictors are generated using separate models. ACWT is obtained using a NAVSUP model called the Budget and Readiness (BAR) which uses budget items to compute ACWT. RFI is obtained from another Mathtech model called the Inventory Model. The accuracy of these two models will not be discussed in this thesis.

[2] Model specification was: $RFI=\beta_0+\beta_1x+\beta_2x^2+\beta_3x^3$

Type	Class	Type	Class	Type	Class
AD	Dixie	ATF	Cherokee*	DDG	Coontz
	Samuel Gompers	ATS	Edenton	FF	Bronstein
	Yellowstone	AVM	Great Republic		Garcia
AE	Suribachi	CG	Belknap		Knox
	Nitro		Leahy	FFG	Brooke
AFS	Mars	CGN	Bainbridge*		Oliver H. Perry
AGF	Flagship (Conv LPD)		California	LCC	Blue Ridge
AO	Cimarron		Long Beach	LHA	Tarawa
	Jumbo		Truxton	LKA	Charleston
AOE	Sacramento		Virginia	LPD	Austin
ARS	Diver	CV	Forrestal		Raleigh
AR	Vulcan		J. F. Kennedy*	LPH	Iwo Jima
AS	Emory S. Land		Kitty Hawk*	LSD	Anchorage
	Fulton		Midway*		Thomaston
	Hunley*	CVN	Enterprise		Whidbey Island
AS	Simon Lake*		Nimitz	LST	Newport
ASR	Chanticleer	DD	Spruance	MSO	Aggressive
	Pigeon	DDG	Charles F. Adams	PHM	Pegasus

Table 3. Ship Classes Included in the SIM.

As in the SRM, each of the six dependent variables in the SIM use a different number and combination of the ship class dummy variables in their submodels. Also, the SIM uses a different combination of the non-ship-class predictor variables from the SRM in each of its submodels. The two additional predictor variables used by the SIM are listed below:

1. Average Customer Wait Time (ACWT).
2. Ready For Issue parts inventories (RFI).

Unlike the SRM, the above eleven predictors are used in different combinations for each of the six submodels. The relationships of the eleven total non-ship-class predictor variables to each of the submodel dependent variables are shown in Table 4.

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* See p.20.

MTTCH	*MTTCC*	*MTTCW*	*NEWHULL*	*NEWCOMM*	*NEWWEAP*
TOP3PR*	TOP3PR*	TOP3PR*	TOP3PR	TOP3PR*	
	APARTPS*	APARTPS	APARTPS	APARTPS*	APARTPS
ALABPS*	ALABPS*	ALABPS	ALABPS	ALABPS*	
			TSLDPE		TSLDPE
				LGLDPE*	LGLDPE
			DEPOTM1*		DEPOTM1*
			MOD*	MOD*	MOD
			HRSUWM1	HRSUWM1*	HRSUWM1
			ORDREW*	ORDREW*	ORDREW
RFI	RFI	RFI*			
			ACWT	ACWT*	ACWT

Table 4. SIM Independent Variables (Non-Ship-Class).

* See p.20.

III. PRELIMINARY DATA ANALYSIS

Both the SRM and SIM models provided by Mathtech will be re-examined in this chapter. First, raw data are analyzed along with descriptive statistics. Secondly, results of initial model fitting of the SRM and SIM are discussed, including the statistical significance tests of various predictor variables. Finally, the two fitted models are compared.

A. DESCRIPTIVE STATISTICS

In order to describe the profile of variables used in the SRM and SIM, summary statistics are given for both dependent and predictor variables for each of the six submodels. To be consistent and to compare each model using the same data, these statistics are summarized based on 3504 observations obtained from 1982-1992. In addition, overall MTTC, NEWCAS, and POTF are obtained along with their descriptive statistics. Overall MTTC was calculated by taking the mean of $MTTC_{HULL}$, $MTTC_{COMM}$, and $MTTC_{WEAP}$, weighted by the number of CASREPs produced in each area. Overall NEWCAS was obtained by adding the number of CASREPs produced in each category (HULL, COMM, and WEAP) for each year.

1. Dependent Variables

Descriptive statistics of the dependent variables are displayed in Table 5. Note that there are two POTF values given. $POTF_{FLEET}$ is the weighted fleet average, and $POTF_{SHIP}$ is the hull level POTF. The descriptive statistics for $POTF_{FLEET}$ were computed on an aggregated annual basis, while all others were computed at the hull level. The large difference between $POTF_{SHIP}$ and $POTF_{FLEET}$ is due to the effect of applying the weighting to obtain the fleet value. Since $POTF_{FLEET}$ is lower than $POTF_{SHIP}$, this indicates that the ships with higher operating tempos also spend more annual time in a CASREP

status. The overall average mean time to correct a CASREP turns out to be nearly 20 days. As evident from Table 5, CASREPs in the Hull/Mechanical category (5.3) take substantially more time to correct than those in the Command, Control, and Communications and Weapons categories. Also, the mean value of NEWCAS (8.9) indicates that each ship had an average of nearly nine CASREPs each year. Again, the Hull/Mechanical category dominates the other two categories, with a substantially higher average number of annual CASREPs. Additionally, the Command, Control, and Communications category has the least average number of annual CASREPs and takes less time to correct them than the other two categories. Annual descriptive statistics are given in Appendix G.

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
$POTF_{SHIP}$	69. 4	23.6	0.0	100.0
$POTF_{FLEET}$	59. 8	7.6	44.3	69.2
MTTC (days)	19.6	17.8	1.0	226.0
$MTTC_{HULL}$ (days)	17.7	20.3	0.0	253.0
$MTTC_{COMM}$ (days)	11.6	17.4	0.0	217.0
$MTTC_{WEAP}$ (days)	13.8	28.8	0.0	521.0
NEWCAS (per year per ship)	8.9	7.6	1.0	63.0
$NEWCAS_{HULL}$ (per year per ship)	5.3	5.4	0.0	44.0
$NEWCAS_{COMM}$ (per year per ship)	1.8	2.5	0.0	39.0
$NEWCAS_{WEAP}$ (per year per ship)	2.1	2.9	0.0	35.0

Table 5. Dependent Variable Descriptive Statistics.

2. Predictor Variables

Table 6 gives descriptive statistics of the predictor variables used in both the SRM and the SIM, excluding the dummy variables used to account for ship class. As in Table 5, these are overall statistics obtained based on 1982-1992 data. Annual descriptive statistics are supplied in Appendix G. RFI and ACWT are used exclusively in the SIM, while all other predictor variables listed in Table 6 are used in both the SRM and SIM. Since MOD is used as an indicator variable for whether a ship uses a modified COSAL system (zero means it does not have the system, one means it does), it ranges from zero to one and the small mean indicates there are not many ships which have the modified system. Most values appear reasonable, however, the negative value for the minimum of DEPOTM1 indicates that a ship was reimbursed for repairs in a depot event.

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
TOP3PR (per ship)	0.06663	0.01812	0	0.2
APARTPS ($M per ship per year)	2.57644	0.38491	2.1046	3.3111
ALABPS ($M per ship)	12.40479	1.1431	10.607	15.577
ORDREW ($ per ship per year)	55467.17	251422.7	0	7426160
HRSUWM1 (hours per ship per year)	2281.04	1244.23	0	5757
LGLDPE (days)	137.49	126.30	0	1096
TSLDPE (days)	447.90	449.73	0	3651
DEPOTM1 ($ spent on last depot event)	5823734	14113041	-62619.3	2.67E+08
MOD	0.05537	0.22873	0	1
RFI (parts inventory level per year)	2747.1	740.86	1106	3484
ACWT (days)	426.78	84.689	284	563

Table 6. Predictor Variable Descriptive Statistics.

Scatter plots between the dependent variables and predictors were also produced. Patterns of the data were evaluated to determine any potential relationships between the predictor variables and the various submodel dependent variables. Due to the large number of plots that were made, only representative plots are given. These plots are very similar to the subset dependent variable plots. Figure 2 shows the plot for overall MTTC against the predictor variables used in the MTTC submodels. Since APARTPS and ALABPS are annual amounts of part and labor expenditures spread evenly among all ships each year, they appear as discrete values when plotted. None of the plots shown display a clear trend, although these graphs do not display the effect of the individual

predictor variables when others are included in the models. Figure 3 shows overall NEWCAS against selected predictor variables used in the NEWCAS submodels. Again, it is difficult to pick out a clear trend in any of the plots.

Figure 4 displays the additional SIM variable RFI plotted against the MTTC submodels, and Figure 5 displays ACWT plotted against the NEWCAS submodels. As with the other plots of a single predictor against a dependent variable, these relationships are difficult to distinguish. The discrete values for RFI and ACWT are a result of using annual fleet-wide values for these predictors. The expected relationship of RFI to all three SIM MTTC submodels is negative, meaning that as the inventory of ready for issue parts increases, MTTC decreases. The expected relationship of ACWT to all three SIM NEWCAS submodels is positive, meaning that as the average time a ship waits for a part to arrive increases, NEWCAS also increases. However, these relationships are difficult to certify by examining the plots.

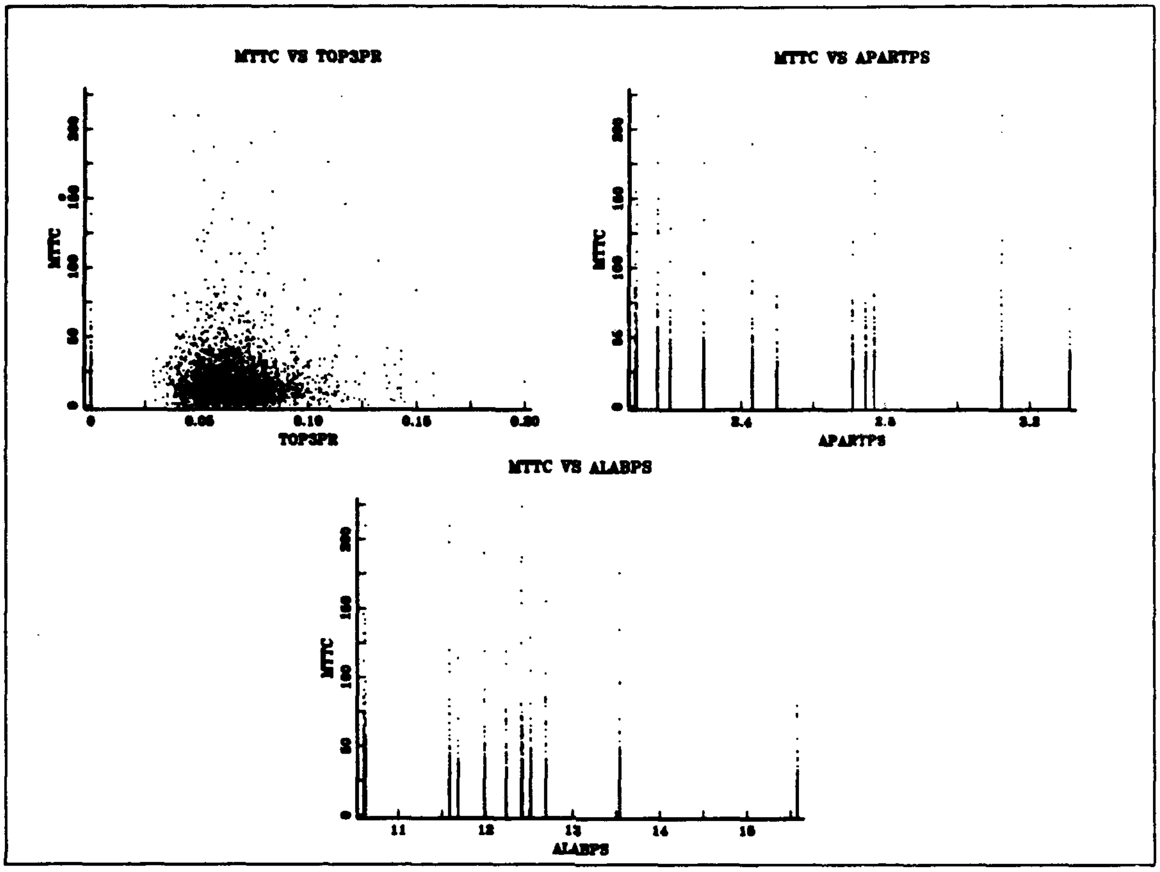

Figure 2. MTTC vs Predictor Variables.

B. INITIAL MODEL FIT

To understand and evaluate model performance, both SRM and SIM were fitted based on the entire data set. Appendices A and B show the code used to perform these model runs for the SRM and SIM respectively. The only modifications made to Mathtech's SAS [Ref. 7] programs were those required to make them run on the local Naval Postgraduate School computer and those required to obtain the necessary information for comparison and validation purposes. To ensure that results obtained from these model runs were consistent with model runs made by Mathtech, the fit of a SRM $MTTC_{HULL}$ submodel was obtained from Mathtech. Compared to the fit obtained locally it was identical.

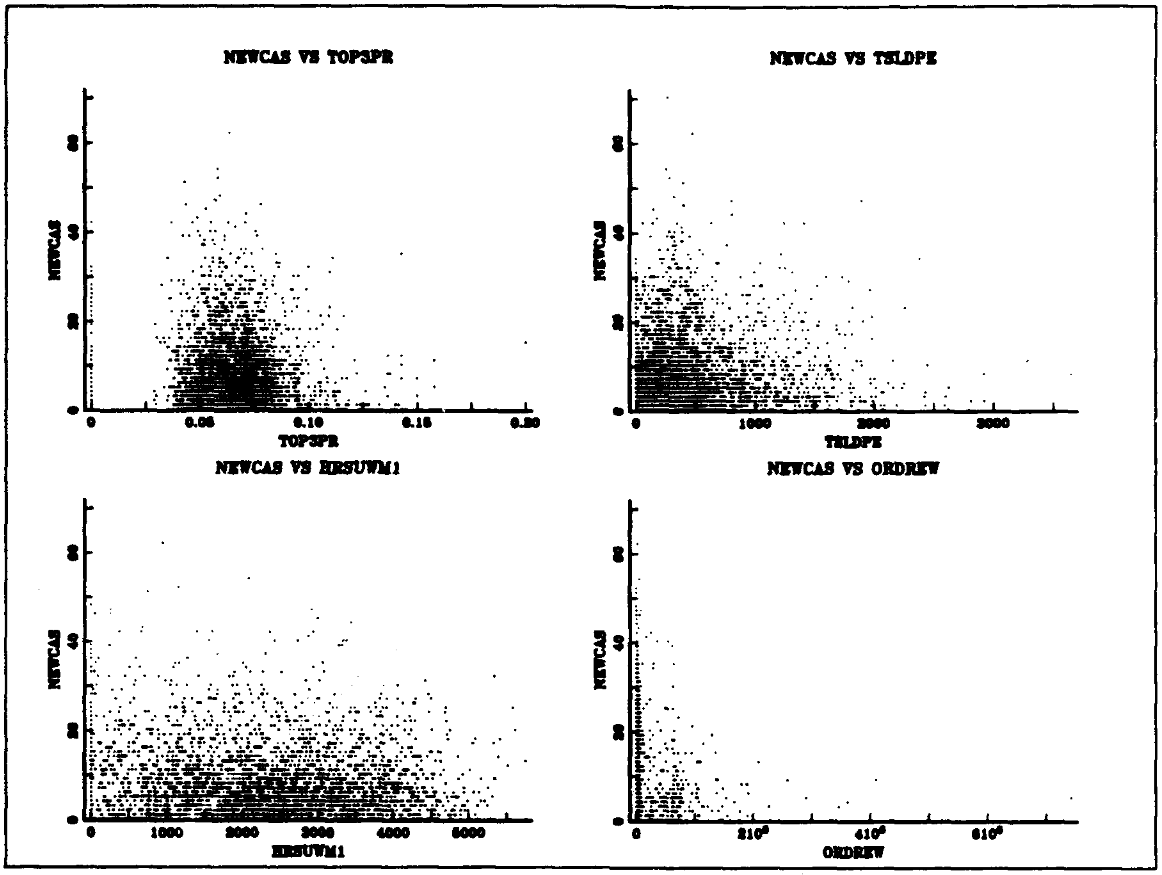

Figure 3. NEWCAS vs Predictor Variables.

1. SRM Fit

Results of the SRM model run are listed in Appendix C. Displayed there are the predicted model coefficients and the model fit statistics for each submodel. Some of the predictor variable coefficients were not statistically significant at the five percent significance level. This means that the marginal contribution of each variable to the model fit is not significant provided that the other remaining variables are in the model. The insignificant predictor variables are marked by asterisks in Table 2. Additionally, thirteen of the ship class dummy variables included in the SRM turned out to be insignificantly different from the reference group in predicting any of the dependent variables. These are highlighted by asterisks in Table 1.

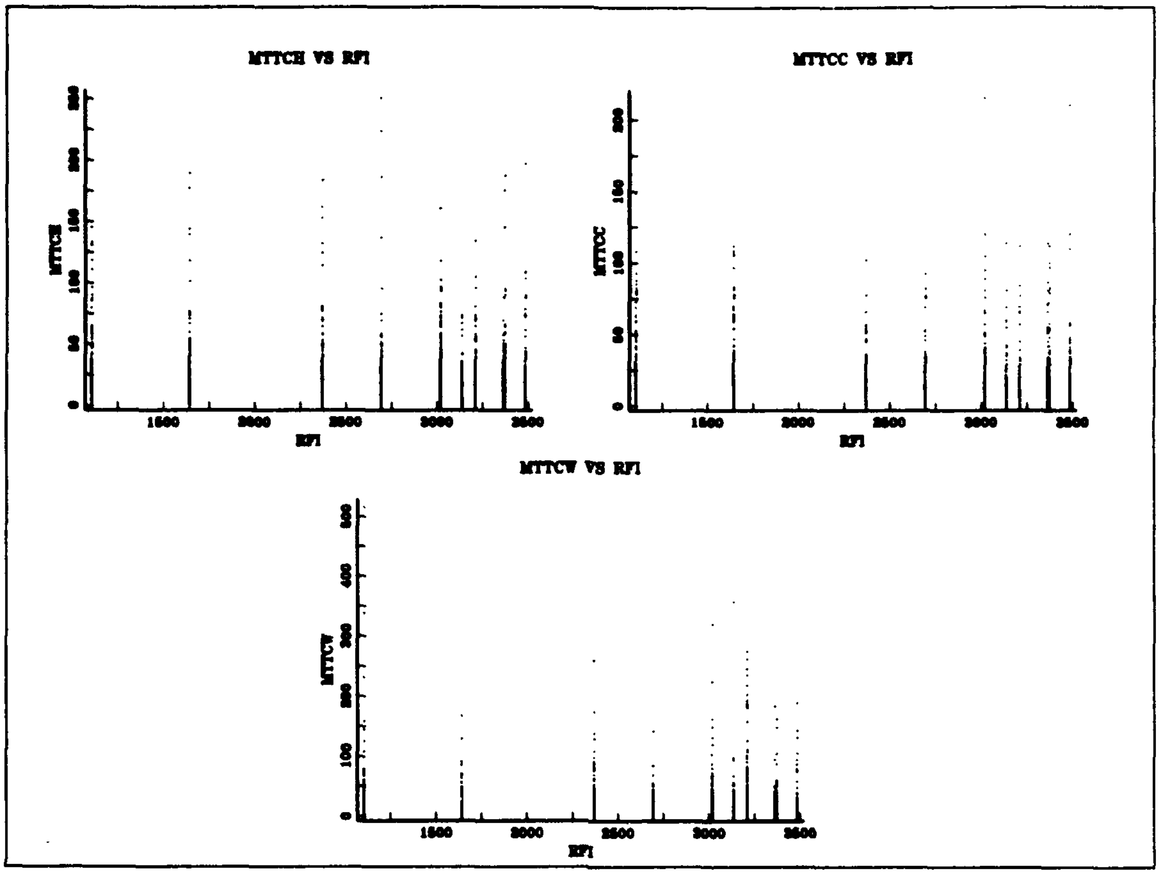

Figure 4. MTTC Submodels vs RFI.

2. SIM Fit

Results of the SIM fit are listed in Appendix D. In Appendix D the predicted model coefficients and the model fit statistics for each submodel are displayed. As with the SRM, it is observed by looking at the model coefficient confidence intervals that some of the predictor variable coefficients were not statistically significant at the five percent significance level. The eleven non-ship-class predictor variables were not significant contributors to some of the dependent variables. These cases are marked by asterisks in Table 4. Additionally, seven of the ship class dummy variables included in the SIM turned out to be insignificantly different from the reference group in predicting any of the dependent variables. These are highlighted by asterisks in Table 3.

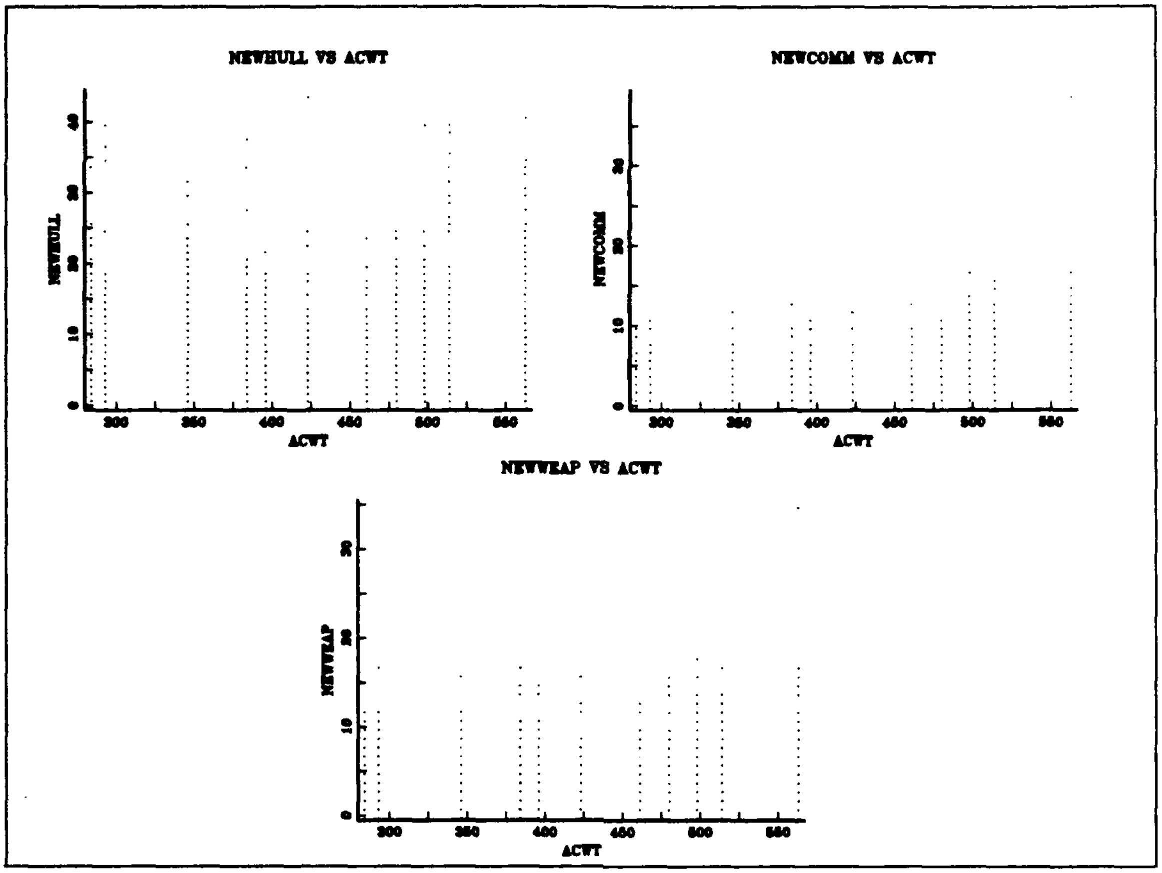

Figure 5. NEWCAS Submodels vs ACWT.

3. Performance of SRM

Performance of the SRM based on the full data set from 1982-1992 is shown in Table 7. The mean overall predicted values for the six dependent variables and predictions for overall MTTC, NEWCAS, and POTF are shown. The Mean Square Errors (MSE) are the means of the squared difference between the predicted values and the actual values for each dependent variable. Therefore, the square root of MSE would reflect the average size of the error. Mean Relative Errors are the means of the relative error defined by the ratio of the absolute errors to the actual values for each dependent variable. The MRE indicates the average percentage error of the fitted model.

Variable	Mean Predicted Values	Mean Square Errors (MSE)	Square Root of MSE	Mean Relative Errors (MRE)
$POTF_{SHIP}$	68.011	490.392	22.145	0.812
$POTF_{FLEET}$	59.884	15.273	3.908	0.055
MTTC	17.350	375.885	19.388	0.722
NEWCAS	9.644	52.598	7.252	1.191
$MTTC_{HULL}$	18.308	413.766	20.341	1.061
$MTTC_{COMM}$	12.881	412.539	20.311	0.885
$MTTC_{WEAP}$	15.897	847.246	29.107	0.854
$NEWCAS_{HULL}$	5.510	26.436	5.142	1.040
$NEWCAS_{COMM}$	1.967	5.351	2.313	0.618
$NEWCAS_{WEAP}$	2.167	6.177	2.485	0.724

Table 7. SRM Fit Results.

Note that except for $POTF_{FLEET}$, these predictions are based on averages at the ship level. Thus, the SRM is a poor prediction model for MTTC, NEWCAS, and $POTF_{SHIP}$ at the ship level. The performance of the SRM improves substantially when $POTF_{SHIP}$ is weighted for individual ship operating tempo contributions and aggregated. The very small MRE value of 0.055 for $POTF_{FLEET}$ indicates that the predicted value differs from the actual value by an average of 5.5 percent. This shows that once $POTF_{SHIP}$ is weighted for individual ship operating tempo contributions and aggregated, the model performs very well. Annual mean relative errors are given in Appendix H.

4. Performance of SIM

The SIM was run using the full model and data set consisting of observations from 1982-1992. Performance of the model fit is shown in Table 8. As with the SRM, the large values of Mean Relative Error indicate that the model is a poor predictor of the dependent variables at the ship hull level. Mean relative errors on an annual basis are given in Appendix I.

Variable	*Mean Predicted Values*	*Mean Square Errors (MSE)*	*Square Root of MSE*	*Mean Relative Errors (MRE)*
POTF	71.118	490.123	22.139	0.794
$POTF_{FLEET}$	61.104	10.832	3.291	0.048
MTTC	16.175	347.228	18.634	0.696
NEWCAS	9.001	49.888	7.063	1.171
$MTTC_{HULL}$	17.653	374.681	19.357	1.048
$MTTC_{COMM}$	11.655	279.171	16.708	0.860
$MTTC_{WEAP}$	14.595	797.322	28.237	0.914
$NEWCAS_{HULL}$	4.948	25.179	5.018	0.960
$NEWCAS_{COMM}$	1.845	4.855	2.203	0.574
$NEWCAS_{WEAP}$	2.208	6.295	2.509	0.672

Table 8. SIM Fit Results.

It is observed that the SIM performed slightly better at predicting all variables except $MTTC_{WEAP}$. Overall, the SIM appears to perform better than the SRM at both the ship level as well as the aggregated fleet level. Particularly, the SIM performed better at predicting the variable of interest, $POTF_{FLEET}$.

IV. MODEL COMPARISONS

In the following chapter, the procedures used for validating and comparing both the SRM and SIM are discussed. The validation is necessary to examine the accuracy of predictions made by the models and to provide a starting point from which to ultimately compare the effectiveness of the two models. The validation is accomplished using the cross validation method. To determine whether the SRM and SIM will make similar predictions of POTF, the jackknife method is used. Results of the validation and comparisons are displayed and analyzed.

A. MODEL VALIDATION

To investigate the predictive power of the models, the cross validation method is used. This method consists of first splitting the data set into two subsets: a construction set and a validation set. The regression models are fitted using the construction set and the fitted model is applied to the validation set to predict the dependent variables. These predicted values are compared with the actual values to determine how well the models perform. In this thesis, the data set was split by years. Both the SRM and SIM used the years 1982-1990 for the construction set and 1991-1992 for the validation set. The SAS code used to accomplish this validation is in Appendices E and F. Since it is desired to determine the predictive power of the models, it is useful to conduct analysis on the basis of annual predictions. The choice for the particular validation set (1991-1992) attempts to mirror the application of the model to the real world. In general, readiness predictions are made based on performance of data taken from the past. This is the primary reason the construction set was chosen to be observations from the consecutive years 1982-1990 and the validation set was chosen to be observations from the years 1991 and 1992. This

has the same effect as if the analysis is being conducted in 1990 with full knowledge of what will occur in 1991 and 1992.

Tables 9 and 10 give relative measures of the effectiveness of the SRM for predicting POTF values for 1991 and 1992, respectively. Note that the values for $POTF_{FLEET}$ are weighted for ship operating tempo. The MRE for $POTF_{FLEET}$ are based on one number per year, therefore, these values can be considered relative errors vice mean relative errors.

Variable	*Mean Predicted Values*	*Mean Square Errors (MSE)*	*Square Root of MSE*	*Mean Relative Errors (MRE)*
$POTF_{FLEET}$	58.776	10.073	3.174	0.057
$POTF_{SHIP}$	74.784	529.069	23.002	0.331
MTTC	15.610	345.035	18.575	0.933
NEWCAS	7.985	51.241	7.158	0.793
$MTTC_{HULL}$	15.582	482.961	21.976	1.184
$MTTC_{COMM}$	7.440	272.003	16.493	1.565
$MTTC_{WEAP}$	16.000	418.559	20.459	1.765
$NEWCAS_{HULL}$	4.953	30.702	5.541	0.976
$NEWCAS_{COMM}$	1.381	2.974	1.725	1.218
$NEWCAS_{WEAP}$	1.652	5.924	2.434	1.257

Table 9. 1991 SRM Validation Results.

Variable	*Mean Predicted Values*	*Mean Square Errors (MSE)*	*Square Root of MSE*	*Mean Relative Errors (MRE)*
$POTF_{FLEET}$	64.509	48.569	6.969	0.121
$POTF_{SHIP}$	85.414	534.040	23.109	0.309
MTTC	11.942	168.895	12.996	0.783
NEWCAS	5.641	51.696	7.190	0.862
$MTTC_{HULL}$	11.445	163.502	12.787	0.883
$MTTC_{COMM}$	3.716	272.360	16.503	1.929
$MTTC_{WEAP}$	13.861	676.170	26.003	2.215
$NEWCAS_{HULL}$	3.756	28.406	5.330	0.946
$NEWCAS_{COMM}$	0.764	2.972	1.724	1.477
$NEWCAS_{WEAP}$	1.121	4.270	2.067	1.342

Table 10. 1992 SRM Validation Results.

As displayed in Tables 9 and 10, the MTTC and NEWCAS submodels fitted based 1982-1990 and applied to 1991 and 1992 provide large values for MRE varying from 0.883 to 2.215. Since this means that the average relative error of the SRM submodels v from 88 percent to 215 percent of the actual value, the SRM submodel predictions are not accurate at the hull level.

The prediction ability improves somewhat for ship level POTF, but 0.331 for 1991 and 0.309 for 1992 are still high values. However, when the fleet level POTF is generated, the average relative of the SRM decrease to about 5.7 percent for 1991 and 12.1 percent for 1992. This vast improvement in the prediction capability of the model when $POTF_{SHIP}$ is aggregated to the fleet level is astounding, however, the reasons for such improvement are not explored in this thesis.

Similarly, results of the cross validation of the SIM are given in Tables 11 and 12 for 1991 and 1992. Large MRE values varying from 95 percent to 232 percent of the actual value indicate that the prediction ability of the SIM submodels at the hull level are also not accurate.

As with the SRM, prediction ability improves somewhat for the SIM ship level POTF, but 0.361 for 1991 and 0.316 for 1992 are still high values. However, when the fleet level POTF is generated, the relative errors between the predicted $POTF_{FLEET}$ and the actual $POTF_{FLEET}$ decrease to about 14.4 percent for 1991 and 4.4 percent for 1992. This is similar to the vast improvement in prediction capability of the SRM when $POTF_{SHIP}$ is aggregated to the fleet level.

Variable	*Mean Predicted Values*	*Mean Square Errors (MSE)*	*Square Root of MSE*	*Mean Relative Errors (MRE)*
$POTF_{FLEET}$	63.623	64.324	8.020	0.144
$POTF_{SHIP}$	80.196	630.362	25.107	0.361
MTTC	15.068	352.717	18.781	0.943
NEWCAS	6.201	60.225	7.761	0.859
$MTTC_{HULL}$	15.351	479.099	21.888	1.179
$MTTC_{COMM}$	8.012	265.436	16.292	1.546
$MTTC_{WEAP}$	15.942	403.950	20.098	1.734
$NEWCAS_{HULL}$	3.932	33.376	5.777	1.017
$NEWCAS_{COMM}$	0.730	3.751	1.937	1.368
$NEWCAS_{WEAP}$	1.538	6.305	2.511	1.296

Table 11. 1991 SIM Validation Results.

Variable	*Mean Predicted Values*	*Mean Square Errors (MSE)*	*Square Root of MSE*	*Mean Relative Errors (MRE)*
$POTF_{FLEET}$	60.096	6.534	2.556	0.044
$POTF_{SHIP}$	78.241	558.471	23.632	0.316
MTTC	16.560	180.811	13.447	0.810
NEWCAS	6.255	51.415	7.170	0.860
$MTTC_{HULL}$	18.197	189.883	13.780	0.951
$MTTC_{COMM}$	7.920	251.462	15.858	1.854
$MTTC_{WEAP}$	12.545	743.038	27.259	2.322
$NEWCAS_{HULL}$	4.399	29.587	5.439	0.966
$NEWCAS_{COMM}$	0.499	3.369	1.835	1.572
$NEWCAS_{WEAP}$	1.357	4.267	2.066	1.341

Table 12. 1992 SIM Validation Results.

Comparing the Tables 9 and 10 with Tables 11 and 12, it can be seen that the SRM predicts the value of $POTF_{FLEET}$ closer to the actual value for 1991, and the SIM predicts the value of $POTF_{FLEET}$ closer to the actual value for 1992. At the ship level, the SRM tends to predict closer values for POTF for both 1991 and 1992. Also, it is interesting to note that the SRM predicts closer values for all the NEWCAS submodels in 1991, and the SIM predicted closer values for all the MTTC submodels in 1991. Predictions for the 1992 submodels were mixed, with the SRM predicting closer values

to the actuals in two out of three of the MTTC submodels and two out of three of the NEWCAS submodels.

These observations reveal that the SRM tends to predict POTF and the NEWCAS and MTTC submodels better than the SIM at the hull level. However, the cross validation gives mixed results when POTF is aggregated to produce the primary variable of interest, $POTF_{FLEET}$; the SRM predicts a better value for $POTF_{FLEET}$ for 1991, and the SIM predicts a better value for 1992. Using the chosen construction and validation sets, neither model significantly outperforms the other at the fleet level. Cross validation results are based on only two sets of data: construction and validation sets. Therefore, to generalize these results, the jackknife procedure was used.

B. JACKKNIFE PROCEDURE

In order to compare the two models, it was necessary to find a method to obtain confidence intervals for the expected $POTF_{FLEET}$ based on each model. This was to accomplish two main goals, namely, to directly compare the confidence intervals of $POTF_{FLEET}$ from the SRM with those from the SIM, and to provide another measure of both models' predictive powers by ascertaining whether the confidence intervals produced would contain the actual values of $POTF_{FLEET}$.

A resampling method, called the jackknife procedure [Ref. 6], was used to accomplish these goals. The jackknife approach was utilized to produce confidence intervals for $POTF_{FLEET}$ by the following method. The jackknife procedure eliminates ten observations from the data set and fits the model using the remaining observations. The fitted models then can be used to predict $POTF_{FLEET}$ of the full data set. Next, the eliminated observations are put back into the data set and ten different observations are eliminated. The model is fitted again with the remaining observations and another

prediction for $POTF_{FLEET}$ is obtained. This process continues until the last set of ten observations is eliminated. It was decided to produce a total of 120 predictions of POTF per year. This was due primarily to the large amount of time and computing resources that this procedure requires. Jackknifing the SRM 120 iterations took 288 minutes of CPU time and jackknifing the SIM 120 iterations took 216 minutes of CPU time. It should be noted that in order to avoid biasing the results toward a specific year of the data set, the observations were iteratively taken out at regularly spaced points spanning the entire data set. The 120 predictions thus produced were then plotted and the outside 2.5 percent from both tail areas were eliminated. The bounds of the remaining predictions represent a 95 percent confidence interval for the expected $POTF_{FLEET}$.

It was desired to compare the annual and the overall confidence intervals of POTF weighted for ship operating tempo contributions. If both SRM and SIM confidence intervals for $POTF_{FLEET}$ overlap, that indicates that the two models can be expected to predict statistically similar values of $POTF_{FLEET}$. Additionally, if the confidence intervals are close to or contain the actual values of $POTF_{FLEET}$, then the model predictions can be considered reasonable. Table 13 gives a direct comparison of these intervals and Figure 6 displays a plot of the jackknifed 95 percent confidence intervals and the actual values.

Year	SRM 95% C.I. (lower/upper)	SIM 95% C.I. (lower/upper)	C.I. Overlap?	Actual Mean Value	Actual in C.I.?
Overall	0.5738	0.6043	No	0.5978	
	0.5830	0.6194			
1982	0.3886	0.4003	No	0.4426	
	0.3997	0.4218			
1983	0.5636	0.5201	No	0.5423	
	0.5733	0.5352			
1984	0.6370	0.5945	No	0.5650	
	0.6465	0.6074			
1985	0.6492	0.6293	No	0.6325	SIM
	0.6591	0.6420			
1986	0.6506	0.6624	No	0.6872	
	0.6610	0.6753			
1987	0.6929	0.7134	No	0.6921	
	0.7020	0.7238			
1988	0.6712	0.7206	No	0.6825	
	0.6809	0.7305			
1989	0.5542	0.6250	No	0.6354	SIM
	0.5661	0.6382			
1990	0.5112	0.5936	No	0.5649	
	0.5225	0.6064			
1991	0.5587	0.6213	No	0.5560	
	0.5686	0.6314			
1992	0.6120	0.5954	No	0.5754	
	0.6215	0.6061			

Table 13. 95% Jackknife Confidence Intervals for $POTF_{FLEET}$.

As displayed in Table 13, none of the 95 percent confidence intervals overlap. This implies that the SIM and SRM tend to predict different values for $POTF_{FLEET}$ at the five percent significance level. Also, none of the SRM confidence intervals include the actual mean values. The SIM has two confidence intervals which contain actual values of $POTF_{FLEET}$.

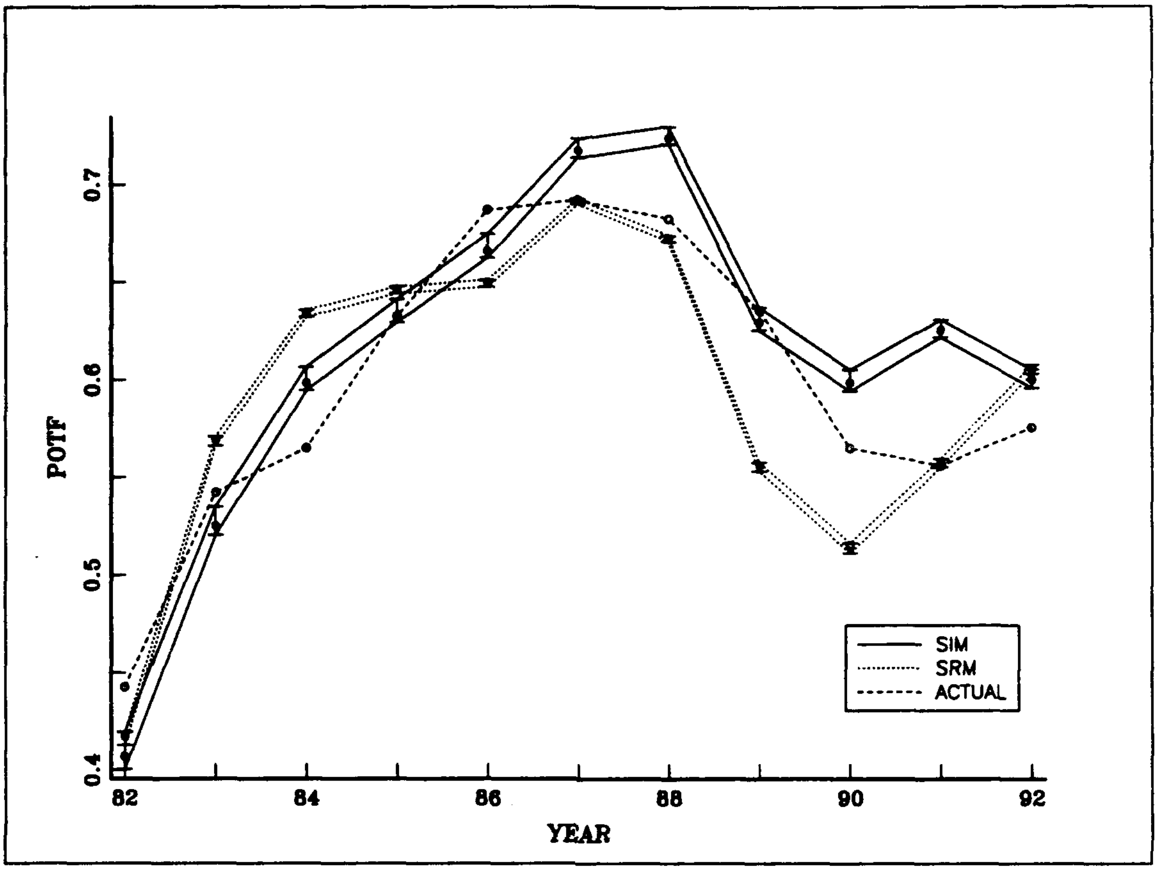

Figure 6. Jackknife Confidence Intervals.

Although the cross validation showed that neither model outperformed the other when using the years 1982-1990 as the construction set, the jackknife indicates that the SIM tends to predict slightly better over the entire range. In accordance with the outcomes found in the cross validation, the jackknife shows that the SRM predicts an interval much closer to the actual value than the SIM for 1991, and the SIM predicts an interval much closer to the actual value than the SRM for 1992. This mixed result affirms the cross validation conclusions for 1991 and 1992.

The SIM confidence intervals were closer than the SRM confidence intervals to the actual values for $POTF_{FLEET}$ eight of the eleven years and also for the overall values. Additionally, since two of the SIM confidence intervals and none of the SRM confidence

intervals contained the actual value for $POTF_{FLEET}$, the SIM performed marginally better than the SRM based on this jackknife.

V. CONCLUSIONS

In this chapter the major findings are summarized and recommendations are made. Also discussed are areas for further research.

A. SUMMARY OF GOALS AND METHODS

The primary goal of this thesis was to compare the SIM to the SRM in order to determine whether the SIM tends to predict a significantly different level of readiness from the SRM. The secondary goal was to provide a validation of both model fits in order to provide a means for evaluating the effectiveness of the predictions obtained by both models.

To achieve these goals, several methods are employed. After examining the data set, both models are fitted based on entire data set available. Next, cross validation is applied to each model to determine the effectiveness of their predictions. Finally, to determine whether the models predict different values of $POTF_{FLEET}$, the jackknife technique is employed.

B. SUMMARY OF RESULTS

When the models were fitted based on the entire data set, there were several insignificant predictor variables and ship-class dummy variables in each submodel. This raises the question of why these insignificant variables are kept in the models. It may be worth the effort to examine model performance using reduced models after examining the effect of eliminating one or more of the insignificant predictor variables.

Performances of both the SRM and SIM based on the full data set were evaluated in terms of MRE. Relatively large MRE for POTF at the ship level confirms what is widely known at OPNAV N814 and Mathtech, that the SRM and SIM are poor

predictors of readiness at the individual ship level. However, the performance at the fleet level increases substantially. The MRE associated with the overall prediction for $POTF_{FLEET}$ based on the SRM was only an average of 5.5 percent, and was only an average of 4.8 percent for the SIM. The small values for MRE for $POTF_{FLEET}$ indicate that both models work quite well in predicting the aggregated fleet level readiness indicator. However, at the ship level, MREs are 81 percent and 79 percent for the SRM and SIM respectively. Additionally, based on the MRE criteria, the SIM performs slightly better than the SRM in predicting an overall fleet POTF.

The cross validation, using 1982-1990 for the construction set and 1991-1992 for the validation set gave mixed results. The SRM performed better at making predictions for $POTF_{FLEET}$ in 1991 and the SIM performed better at making predictions for 1992.

The 95 percent jackknife confidence intervals based on 120 iterations showed that the SIM and SRM will produce significantly different estimates of $POTF_{FLEET}$. Over the 11 year span of predictions, none of the confidence intervals overlapped. Furthermore, the jackknife confidence intervals indicate that the SIM predicts $POTF_{FLEET}$ slightly better than the SRM: first, the SIM produces two confidence intervals which included the actual values of $POTF_{FLEET}$, while the SRM has none; second, the SIM confidence intervals are closer to the actual values for $POTF_{FLEET}$ than the SRM confidence intervals.

The primary suggestion with regard to the jackknife procedure conducted in this analysis is that the number of observations deleted in each iteration may be increased. Had more observations per iteration been deleted, the confidence intervals would have been considerably wider. Deleting more observations per iteration would also result in more intervals containing the actual value for $POTF_{FLEET}$.

C. RECOMMENDATIONS

Since the SRM and SIM turn out to predict different levels of $POTF_{FLEET}$, it is recommended to avoid using both models simultaneously. Both models performed fairly well at the fleet level using MRE as a performance criteria. There were mixed conclusions for both the cross validation results and the jackknife results when attempting to ascertain whether the SRM or the SIM performs better at predicting future levels of $POTF_{FLEET}$. However, the jackknife showed that the SIM performs slightly better than the SRM due to the SIM's confidence intervals being closer to the actual values for $POTF_{FLEET}$. Thus, the marginal performance increase of the SIM must be examined against the marginal cost of including ACWT and RFI in the SIM.

D. FURTHER WORK

There are several areas where further work is needed. First, the jackknife procedure used in this thesis could be modified to exclude more observations per iteration to obtain wider confidence intervals for expected $POTF_{FLEET}$. Second, the empirical distribution of the fitted $POTF_{FLEET}$ values obtained from the jackknife may be examined to produce a more accurate 95 percent confidence interval. Third, both models can be simplified by eliminating insignificant predictor variables. Fourth, residual analysis of the submodels in both the SRM and SIM showed that the residuals do not follow the Normal distribution. Therefore, use of log linear models assuming log normal errors vice nonlinear regression models may be better suited for the submodels and would certainly provide models that would use less computational effort. Fifth, research may be conducted on why both the SRM and SIM perform so well at the fleet level while the submodel performance at the hull level is poor. Last, Poisson regression [Ref. 8] could be performed on the NEWCAS submodels to determine if a better fit can be obtained.

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APPENDIX A. CODE FOR SRM FULL MODEL RUN

Appendix A contains the SAS code that was used to perform the full model run for the SRM.

```
//SRM1C JOB CLASS=C,USER=S6402
//*MAIN LINES=(99)
//*------------------------------------------------------------
//SAS    PROC CONFIG=NULLFILE,OPTIONS=,SORT=4
//SAS608  EXEC PGM=SASHOST,PARM='SORT=&SORT &OPTIONS',REGION=4096K
//CONFIG   DD DISP=SHR,DSN=MSS.C2001.SAS608.BATCHXA
//         DD DISP=SHR,DSN=&CONFIG
//STEPLIB  DD DSN=MSS.C2001.SAS608.LIBRARY,DISP=SHR
//SASHELP  DD DSN=MSS.C2001.SAS608.SASHELP,DISP=SHR
//SASAUTOS DD DSN=MSS.C2001.SAS608.AUTOLIB,DISP=SHR
//SASMSG   DD DSN=MSS.C2001.SAS608.SASMSG,DISP=SHR
//WORK     DD UNIT=SYSDA,SPACE=(23040,(140,50),,,ROUND),
//            DCB=(RECFM=FS,LRECL=23040,BLKSIZE=23040,DSORG=PS)
//SASLOG   DD SYSOUT=A,DCB=(BLKSIZE=141,LRECL=137,RECFM=VBA)
//SASLIST  DD SYSOUT=A,DCB=(BLKSIZE=141,LRECL=137,RECFM=VBA)
//SASPARM  DD UNIT=SYSDA,SPACE=(400,(100,300)),
//            DCB=(RECFM=FB,LRECL=80,BLKSIZE=400,BUFNO=1)
//PUNCH    DD SYSOUT=B,DCB=(RECFM=F,BLKSIZE=80)
// PEND
//*------------------------------------------------------------
// EXEC SAS
//WORK DD UNIT=SYSDA,SPACE=(CYL,(100,5))
//PDAT DD UNIT=SYSDA,DISP=SHR,DSN=MSS.S6402.FY92.POTF
//REG2 DD DISP=SHR,DSN=MSS.S6402.MATHTECH
//NEWDAT DD DISP=(NEW,CATLG),UNIT=SYSDA,
// SPACE=(TRK,(260,1),RLSE),
// DSN=MSS.S6402.FY92.FMDB.LAG
//RESLTZ DD DISP=(OLD,KEEP),UNIT=SYSDA,
// SPACE=(TRK,(10,10),RLSE),
// DSN=MSS.S6402.FY92.RESULTS
//SYSIN DD *

OPTIONS LS=132;
 DATA R2;
 SET REG2.MASTER92;
 IF YEAR > 80;
 IF NEWCAS = 0 THEN DO;
 NEWHULL = 0;
 NEWCOMM = 0;
 NEWWEAP = 0;
 END;
 IF NEWCAS = . THEN DO;
 NEWHULL = .;
```

```
NEWCOMM = .;
NEWWEAP = . ;
END;
IF HRSUWM1 = . THEN HRSUWM1 = 0;
IF OVHLM1= . THEN OVHLM1 = 0;
IF FMPM1=. THEN FMPM1=0;
IF SRAM1=. THEN SRAM1=0;
DEPOTM1 = OVHLM1 + FMPM1 + SRAM1;
DEPOT = OVHL+FMP+SRA;
IF TOP3PR = . THEN TOP3PR = 0;
PROC SORT; BY YEAR;
PROC FREQ;
TABLES YEAR;
TITLE 'YEARS IN NEW DATABASE';

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4 /* MTTC HULL */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP  */ V1=   4.228803        /* TOP3PR   */ V2=  -0.630357
/* APARTPS   */ V3=  -0.272440        /* ALABPS   */ V4=  -0.063706
/* ZLSTNEWP  */ V5=   0.251657        /* ZASRPIGE */ V6=   0.548550
/* ZFFKNOX   */ V7=  -0.411411        /* ZFFGOLIV */ V8=  -0.357471
/* ZMCMAVEN  */ V9=   0.705697        /* ZASFULT  */ V10=  0.854867
/* ZATFCHER  */ V11=  0.839453        /* ZASRCHAN */ V12=  0.265972
/* ZARSDIVE  */ V13=  0.287284        /* ZADSAMU  */ V14=  0.561813
/* ZASEMOR   */ V15= -0.045932        /* ZATSEDEN */ V16=  0.503384
/* ZLSDTHOM  */ V17=  0.379376        /* ZARVULC  */ V18=  0.108876
/* ZAVMCONV  */ V19=  [illegible]3994 /* ZCVNNIMI */ V20=  0.154603
/* ZLKACHAR  */ V21=  0.211833        /* ZAOJUMB */ V22=   0.481713
/* ZCVNENTE  */ V23=  0.647047        /* ZCGTICO  */ V24= -0.349714
/* ZCGBELK */ V25=  -0.311276         /* ZDDGADAM */ V26= -0.172771
/* ZLCCBLUE */ V27= -0.447553         /* ZCGLEAH */ V28=  -0.224259
/* ZDDSPRU   */ V29= -0.160662        /* ZLSDWHID */ V30= -0.216617
/* ZCGNBAIN  */ V31=  0.194365        /* ZAEKILA  */ V32= -0.189876
/* ZFFBRON   */ V33= -0.343888        /* ZLPDAUST */ V34= -0.197907
/* ZAOCIMA   */ V35= -0.378519        /* ZAESURI  */ V36= -0.388261
/* ZAENITR   */ V37= -0.299854 ;

MODEL MTTCH = EXP( V1 + TOP3PR * V2 + APARTPS * V3 + ALABPS * V4 + ZLSTNEWP * V5
+ ZASRPIGE * V6 + ZFFKNOX * V7 + ZFFGOLIV * V8 + ZMCMAVEN * V9 + ZASFULT * V10 +
ZATFCHER * V11 + ZASRCHAN * V12 + ZARSDIVE * V13 + ZADSAMU * V14 + ZASEMOR *
V15 + ZATSEDEN * V16 + ZLSDTHOM * V17 + ZARVULC * V18 + ZAVMCONV * V19 +
ZCVNNIMI * V20 + ZLKACHAR * V21 + ZAOJUMB * V22 + ZCVNENTE * V23 + ZCGTICO * V24
+ ZCGBELK * V25 + ZDDGADAM * V26 + ZLCCBLUE * V27 + ZCGLEAH * V28 + ZDDSPRU *
V29 + ZLSDWHID * V30 + ZCGNBAIN * V31 + ZAEKILA * V32 + ZFFBRON * V33 + ZLPDAUST
* V34 + ZAOCIMA * V35 + ZAESURI * V36 + ZAENITR * V37 );

/* MTTCH HOLDS PRED VALUES AND RESIDUALS */
OUTPUT OUT=MTTCH P=PMTTCH R=RESID;
```

```
PROC SORT; BY YEAR;
/*   PROC PLOT; PLOT RESID*HULL; BY YEAR;
PROC UNIVARIATE PLOT NORMAL;
 VAR RESID;                    */
DATA MTTCH;
SET MTTCH;
IF PMTTCH = . THEN DELETE;
KEEP MTTCH PMTTCH DAYSINC5 TYPE HULL YEAR POTF;

/* SUMMARY BY YEAR OF MTTCH AND PMTTCH */
PROC SUMMARY NWAY DATA=MTTCH;
CLASS YEAR;
VAR MTTCH PMTTCH;

/* OUTPUT PUT IN SET C4--MEAN OF MTTCH AND PMTTCH BY YEAR.PRINTS C4 */
OUTPUT OUT=C4 MEAN=MTTCH PMTTCH;
/*   PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, MTTC HULL';  /
PROC PLOT;
PLOT PMTTCH*YEAR='P'
MTTCH*YEAR='A'/OVERLAY;        */

/* SAVES UNDER MTTCH FILE */
DATA RESLTZ.MTTCH; SET MTTCH;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4 /* MTTC C-CUBED */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP  */ V1=   4.118790          /* TOP3PR    */ V2=  -3.341724
/* APARTPS   */ V3=  -0.215897          /* ALABPS    */ V4=  -0.080318
/* ZADSAMU   */ V5=   0.786661          /* ZAGFFLAG  */ V6=   0.460483
/* ZASRCHAN  */ V7=  -1.057847          /* ZAVMCONV  */ V8=   0.546325
/* ZCGBELK   */ V9=   0.178141          /* ZCGLEAH   */ V10=  0.409823
/* ZCGNTRUX  */ V11=  0.446014          /* ZCGNVIRG  */ V12=  0.168738
/* ZCVFORR   */ V13= -0.009229          /* ZCVKITT   */ V14=  0.175728
/* ZCVNENTE  */ V15=  0.753793          /* ZDDGADAM  */ V16=  0.306384
/* ZDDGCOON  */ V17=  0.332982          /* ZDDHULL   */ V18=  0.236371
/* ZDDSPRU   */ V19=  0.320108          /* ZFFBRON   */ V20=  0.443366
/* ZFFGARC   */ V21=  0.266126          /* ZFFGBROO  */ V22=  0.458080
/* ZFFGOLIV  */ V23=  0.209630          /* ZFFKNOX   */ V24=  0.246602
/* ZLCCBLUE  */ V25=  0.293479          /* ZLHATARA  */ V26=  0.652265
/* ZLPHIWO_  */ V27=  0.451711          /* ZLSTNEWP  */ V28= -0.324879
/* ZMCMAVEN  */ V29=  0.467363          /* ZMSOAGGR  */ V30=  0.210632
/* ZPHMPEGA  */ V31=  0.197774 ;

MODEL MTTCC =
 EXP( V1 + TOP3PR * V2 + APARTPS * V3 + ALABPS * V4 + ZADSAMU * V5 + ZAGFFLAG * V6
+ ZASRCHAN * V7 + ZAVMCONV * V8 + ZCGBELK * V9 + ZCGLEAH * V10 + ZCGNTRUX *
V11 + ZCGNVIRG * V12 + ZCVFORR * V13 + ZCVKITT * V14 + ZCVNENTE * V15 +
ZDDGADAM * V16 + ZDDGCOON * V17 + ZDDHULL * V18 + ZDDSPRU * V19 + ZFFBRON *
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V20 + ZFFGARC * V21 + ZFFGBROO * V22 + ZFFGOLIV * V23 + ZFFKNOX * V24 + ZLCCBLUE
* V25 + ZLHATARA * V26 + ZLPHIWO_ * V27 + ZLSTNEWP * V28 + ZMCMAVEN * V29 +
ZMSOAGGR * V30 + ZPHMPEGA * V31 );

/* MTTCC HOLDS PRED VALUES AND RESIDUALS */
OUTPUT OUT=MTTCC P=PMTTCC R=RESID;
PROC SORT; BY YEAR;
 /*   PROC PLOT;PLOT RESID*HULL; BY YEAR;
PROC UNIVARIATE PLOT NORMAL;
  VAR RESID;                    */
DATA MTTCC;
SET MTTCC;
IF PMTTCC = . THEN DELETE;
KEEP MTTCC PMTTCC DAYSINC5 TYPE HULL YEAR POTF;

/* SUMMARY BY YEAR OF MTTCC AND PMTTCC */
PROC SUMMARY NWAY DATA=MTTCC;
CLASS YEAR;
VAR MTTCC PMTTCC;

/* OUTPUT PUT IN SET C5--MEAN OF MTTCC AND PMTTCC BY YEAR.PRINTS C5 */
OUTPUT OUT=C5 MEAN=MTTCC PMTTCC;
/*   PROC PRINT; TITLE 'AGGREGATE PREDICTED AND ACTUALS: MTTC COMM;  /
PROC PLOT;
PLOT PMTTCC*YEAR='P'
MTTCC*YEAR='A'/OVERLAY;               */
DATA RESLTZ.MTTCC; SET MTTCC;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4 /*  MTTC WEAPONS */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP  */ V1=   4.487560          /* TOP3PR    */ V2=   -0.168410
/* APARTPS   */ V3=   -0.450444         /* ALABPS    */ V4=   -0.067581
/* ZAEKILA   */ V5=   -0.319150         /* ZAFSMARS  */ V6=    0.318038
/* ZAGFFLAG  */ V7=    0.223403         /* ZAOESACR  */ V8=    0.662144
/* ZAORWICH  */ V9=    0.518062         /* ZAVMCONV  */ V10=   0.500249
/* ZBBIOWA   */ V11=  -0.268677         /* ZCGBELK   */ V12=   0.293498
/* ZCGLEAH   */ V13=   0.489604         /* ZCGNBAIN  */ V14=   0.439324
/* ZCGNCALI  */ V15=   0.602315         /* ZCGNLONG  */ V16=   0.645231
/* ZCGNTRUX  */ V17=   0.608886         /* ZCGNVIRG  */ V18=   0.652650
/* ZCGTICO   */ V19=   0.003433         /* ZCVFORR   */ V20=   0.376779
/* ZCVKITT   */ V21=   0.992440         /* ZCVNENTE  */ V22=   0.371362
/* ZCVNNIMI  */ V23=   0.410087         /* ZDDGADAM  */ V24=   0.374494
/* ZDDGCOON  */ V25=   0.312592         /* ZDDGKIDD  */ V26=   0.190677
/* ZDDHULL   */ V27=   0.116067         /* ZDDSPRU   */ V28=   0.166151
/* ZFFBRON   */ V29=   0.322800         /* ZFFGARC   */ V30=   0.586148
/* ZFFGBROO  */ V31=   0.411263         /* ZFFGOLIV  */ V32=   0.168631
/* ZFFKNOX   */ V33=   0.105918         /* ZLCCBLUE  */ V34=   0.979150
/* ZLHATARA  */ V35=   0.661584         /* ZLPDAUST  */ V36=   0.047642
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/* ZLPHIWO_  */ V37=   0.659883          /* ZLSDWHID  */ V38=   0.047849
/* ZLSTNEWP  */ V39=  -0.110661          /* ZMCMAVEN  */ V40=   1.268851
/* ZMSOAGGR  */ V41=   0.538711          /* ZPHMPEGA  */ V42=  -0.078196 ;

MODEL MTTCW = EXP( V1 + TOP3PR * V2 + APARTPS * V3 + ALABPS * V4 + ZAEKILA * V5
+ ZAFSMARS * V6 + ZAGFFLAG * V7 + ZAOESACR * V8 + ZAORWICH * V9 + ZAVMCONV *
V10 + ZBBIOWA * V11 + ZCGBELK * V12 + ZCGLEAH * V13 + ZCGNBAIN * V14 + ZCGNCALI
* V15 + ZCGNLONG * V16 + ZCGNTRUX * V17 + ZCGNVIRG * V18 + ZCGTICO * V19 +
ZCVFORR * V20 + ZCVKITT * V21 + ZCVNENTE * V22 + ZCVNNIMI * V23 + ZDDGADAM *
V24 + ZDDGCOON * V25 + ZDDGKIDD * V26 + ZDDHULL   * V27   + ZDDSPRU * V28 +
ZFFBRON * V29 + ZFFGARC * V30 + ZFFGBROO * V31 + ZFFGOLIV * V32 + ZFFKNOX * V33 +
ZLCCBLUE * V34 + ZLHATARA * V35 + ZLPDAUST * V36 + ZLPHIWO_ * V37 + ZLSDWHID *
V38 + ZLSTNEWP * V39 + ZMCMAVEN * V40 + ZMSOAGGR * V41 + ZPHMPEGA * V42 );

/* MTTCW HOLD PRED VALUE AND RESIDUAL */
OUTPUT OUT=MTTCW P=PMTTCW R=RESID;
PROC SORT; BY YEAR;
/*   PROC PLOT; PLOT RESID*HULL; BY YEAR;
PROC UNIVARIATE PLOT NORMAL;
  VAR RESID;                    */
DATA MTTCW;
SET MTTCW;
IF PMTTCW = . THEN DELETE;
KEEP MTTCW PMTTCW DAYSINC5 TYPE HULL YEAR POTF;

/* SUMMARY BY YEAR OF MTTCW AND PMTTCW */
PROC SUMMARY NWAY DATA=MTTCW;
CLASS YEAR;
VAR MTTCW PMTTCW;

/* OUTPUT PUT IN SET C6--MEAN OF MTTCW AND PMTTCW BY YEAR.PRINTS C6 */
OUTPUT OUT=C6 MEAN=MTTCW PMTTCW;
/* PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, MTTC WEAPONS';
PROC PLOT;
PLOT PMTTCW*YEAR='P'
MTTCW*YEAR='A'/OVERLAY;          */
DATA RESLTZ.MTTCW; SET MTTCW;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4  /* HULL CASREPS */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/*INTERCEP  */ V1=    2.823655           /*TOP3PR    */ V2=   -4.139634
/*APARTPS   */ V3=   -0.365953           /*ALABPS    */ V4=   -0.026621
/*TSLDPE    */ V5=    0.000175           /*LGLDPE    */ V6=  0.000069510
/*DEPOTM1   */ V7= 2.8733378E-9          /*MOD       */ V8=    0.064242
/*HRSUWM1   */ V9= -0.000019688          /*ORDREW    */ V10= -0.000000244
/*ZLPHIWO_  */ V11=   0.543273           /*ZLSDTHOM  */ V12=   0.765392
/*ZAOJUMB   */ V13=   0.785408           /*ZFFGBROO  */ V14=   0.800391
/*ZLSDANCH  */ V15=   0.417234           /*ZLPDRALE  */ V16=   0.935777
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/*ZFFGARC   */ V17=   0.546081          /*ZLPDAUST  */ V18=   0.281042
/*ZFFKNOX   */ V19=   0.242797          /*ZLKACHAR  */ V20=   0.473657
/*ZAVMCONV  */ V21=   0.669525          /*ZPHMPEGA  */ V22=   0.615189
/*ZDDHULL   */ V23=   0.638044          /*ZFFBRON   */ V24=   0.678898
/*ZCGTICO   */ V25=  -0.330073          /*ZASSIMO   */ V26=  -1.444439
/*ZAENITR   */ V27=   0.253087          /*ZASRCHAN  */ V28=  -0.620524
/*ZCGNCALI  */ V29=  -0.750318          /*ZCGNVIRG  */ V30=  -0.362037
/*ZASEMOR   */ V31=  -0.911280          /*ZCVNNIMI  */ V32=  -0.526791
/*ZASFULT   */ V33=  -1.264974          /*ZFFGOLIV  */ V34=  -0.014633
/*ZASLY_S   */ V35=  -1.115984          /*ZLSDWHID  */ V36=  -0.472303
/*ZBBIOWA   */ V37=  -0.444642          /*ZAGFFLAG  */ V38=  -0.524905
/*ZCGNLONG  */ V39=  -0.757403          /*ZCGBELK   */ V40=  -0.118982
/*ZASHUNL   */ V41=  -0.845127          /*ZDDSPRU   */ V42=  -0.069258
/*ZCGLEAH   */ V43=  -0.057361          /*ZMCMAVEN  */ V44=   0.403730
/*ZCVJFK    */ V45=  -0.549779          /*ZAORWICH  */ V46=  -0.178795
/*ZLCCBLUE  */ V47=  -0.109136          /*ZCVNENTE  */ V48=  -0.372017
/*ZARSSAFE  */ V49=  -0.284671 ;

MODEL NEWHULL = EXP( V1 + TOP3PR * V2 + APARTPS * V3 + ALABPS * V4 + TSLDPE * V5
+ LGLDPE * V6 + DEPOTM1 * V7 + MOD * V8 + HRSUWM1 * V9 + ORDREW * V10 +
ZLPHIWO_ * V11 + ZLSDTHOM * V12 + ZAOJUMB * V13 + ZFFGBROO * V14 + ZLSDANCH *
V15 + ZLPDRALE * V16 + ZFFGARC * V17 + ZLPDAUST * V18 + ZFFKNOX * V19 + ZLKACHAR
* V20 + ZAVMCONV * V21 + ZPHMPEGA * V22 + ZDDHULL * V23 + ZFFBRON * V24 +
ZCGTICO * V25 + ZASSIMO * V26 + ZAENITR * V27 + ZASRCHAN * V28 + ZCGNCALI * V29 +
ZCGNVIRG * V30 + ZASEMOR * V31 + ZCVNNIMI * V32 + ZASFULT * V33 + ZFFGOLIV * V34
+ ZASLY_S * V35 + ZLSDWHID * V36 + ZBBIOWA * V37 + ZAGFFLAG * V38 + ZCGNLONG *
V39 + ZCGBELK * V40 + ZASHUNL * V41 + ZDDSPRU * V42 + ZCGLEAH * V43 + ZMCMAVEN
* V44 + ZCVJFK * V45 + ZAORWICH * V46 + ZLCCBLUE * V47 + ZCVNENTE * V48 +
ZARSSAFE * V49 );

/* NHULL HOLDS PREDICTED VALUE AND RESIDUAL */
OUTPUT OUT=NHULL P=PNHULL R=RESID;
PROC SORT; BY YEAR;
/*   PROC PLOT; PLOT RESID*HULL; BY YEAR;
PROC UNIVARIATE PLOT NORMAL;
  VAR RESID;                     */
DATA NHULL;
SET NHULL;
IF PNHULL = . THEN DELETE;
KEEP NEWHULL PNHULL DAYSINC5 TYPE HULL YEAR POTF;

/* SUMMARY BY YEAR OF NEWHULL AND PNHULL */
PROC SUMMARY NWAY DATA=NHULL;
CLASS YEAR;
VAR NEWHULL PNHULL;

/* OUTPUT PUT IN SET C1--MEAN OF NEWHULL AND PNHULL BY YEAR.PRINT C1 */
OUTPUT OUT=C1 MEAN=NEWHULL PNHULL;
/*   PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, NEWHULL';
PROC PLOT;
PLOT PNHULL*YEAR='P'
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NEWHULL*YEAR='A'/OVERLAY;            */
DATA RESLTZ.NHULL; SET NHULL;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR OF .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4/* C-CUBED CASREPS */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP  */ V1=   2.272963          /* TOP3PR    */ V2=   -1.336645
/* APARTPS   */ V3=   -0.241792         /* ALABPS    */ V4=   -0.079712
/* TSLDPE    */ V5=  0.000034913        /* LGLDPE    */ V6= -0.000005572
/* DEPOTM1   */ V7= 1.927119E-10        /* MOD       */ V8=   -0.093424
/* HRSUWM1   */ V9= -0.000043100        /* ORDREW    */ V10= -9.784423E-8
/* ZFFGBROO  */ V11=   0.910739         /* ZFFGOLIV  */ V12=   0.491108
/* ZFFKNOX   */ V13=   0.482962         /* ZDDGCOON  */ V14=   0.522015
/* ZDDGADAM  */ V15=   0.432184         /* ZLHATARA  */ V16=   0.617241
/* ZLCCBLUE  */ V17=   0.659701         /* ZFFGARC   */ V18=   0.470064
/* ZCGLEAH   */ V19=   0.450070         /* ZMSOAGGR  */ V20=   0.623990
/* ZCGBELK   */ V21=   0.428599         /* ZFFBRON   */ V22=   0.968922
/* ZCVNENTE  */ V23=   0.976199         /* ZCVKITT   */ V24=   0.398127
/* ZCVFORR   */ V25=   0.120661         /* ZLPHIWO_  */ V26=   0.232026
/* ZCGNVIRG  */ V27=   0.409429         /* ZDDHULL   */ V28=   0.592549
/* ZCGNLONG  */ V29=   0.536128         /* ZCVNNIMI  */ V30=   0.267011
/* ZAGFFLAG  */ V31=   0.246773         /* ZPHMPEGA  */ V32=   0.288956
/* ZCGNCALI  */ V33=   0.263554         /* ZAOESACR  */ V34=   0.334333
/* ZDDSPRU   */ V35=   0.053658         /* ZCGNTRUX  */ V36=   0.394628
/* ZCVJFK    */ V37=   1.069902         /* ZATFCHER  */ V38=   1.285788
/* ZCGNBAIN  */ V39=   0.390543         /* ZAVMCONV  */ V40=   0.292042
/* ZARVULC   */ V41=   0.106421         /* ZASRCHAN  */ V42=   -0.362116 ;

MODEL NEWCOMM =
 EXP( V1 + TOP3PR * V2 + APARTPS * V3 + ALABPS * V4 + TSLDPE * V5 + LGLDPE * V6 +
DEPOTM1 * V7 + MOD * V8 + HRSUWM1 * V9 + ORDREW * V10 + ZFFGBROO * V11 +
ZFFGOLIV * V12 + ZFFKNOX * V13 + ZDDGCOON * V14 + ZDDGADAM * V15 + ZLHATARA *
V16 + ZLCCBLUE * V17 + ZFFGARC * V18 + ZCGLEAH * V19 + ZMSOAGGR * V20 +
ZCGBELK * V21 + ZFFBRON * V22 + ZCVNENTE * V23 + ZCVKITT * V24 + ZCVFORR * V25 +
ZLPHIWO_ * V26 + ZCGNVIRG * V27 + ZDDHULL * V28 + ZCGNLONG * V29 + ZCVNNIMI *
V30 + ZAGFFLAG * V31 + ZPHMPEGA * V32 + ZCGNCALI * V33 + ZAOESACR * V34 +
ZDDSPRU * V35 + ZCGNTRUX * V36 + ZCVJFK * V37 + ZATFCHER * V38 + ZCGNBAIN * V39
+ ZAVMCONV * V40 + ZARVULC * V41 + ZASRCHAN * V42 );

/* NCOMM HOLDS PREDICTED VALUE AND RESIDUAL */
OUTPUT OUT=NCOMM P=PNCOMM R=RESID;
PROC SORT; BY YEAR;
/*   PROC PLOT; PLOT RESID*HULL; BY YEAR;
PROC UNIVARIATE PLOT NORMAL;
  VAR RESID;              */
DATA NCOMM;
SET NCOMM;
IF PNCOMM = . THEN DELETE;
KEEP NEWCOMM PNCOMM DAYSINC5 TYPE HULL YEAR POTF;
```

```
/* SUMMARY BY YEAR OF NEWCOMM AND PNCOMM */
PROC SUMMARY NWAY DATA=NCOMM;
CLASS YEAR;
VAR NEWCOMM PNCOMM;

/* OUTPUT PUT IN SET C2--MEAN OF NEWCOMM AND PNCOMM BY YEAR.PRINTS C2 */
OUTPUT OUT=C2 MEAN=NEWCOMM PNCOMM;
/*   PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, NEWCOMM';
PROC PLOT;
PLOT PNCOMM*YEAR='P'
NEWCOMM*YEAR='A'/OVERLAY;                */

/* SAVE UNDER NCOMM FILE */
DATA RESLTZ.NCOMM; SET NCOMM;

/* PERFORM NONLINEAR REGRESSION STOPPING AT MAX 50 ITERATIONS AND
  USING CONVERGENCE CRITERIA OF .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4/* WEAPONS CASREPS */
CONVERGE = .001 DATA=R2 EFORMAT;

PARMS
/* INTERCEP  */ V1=     1.382563          /* TOP3PR    */ V2=    0.377037
/* APARTPS   */ V3=    -0.177688          /* ALABPS    */ V4=   -0.033994
/* TSLDPE    */ V5=  0.000066152          /* LGLDPE    */ V6=    0.000197
/* DEPOTM1   */ V7= -1.791749E-9          /* MOD       */ V8=    0.169992
/* HRSUWM1   */ V9= -0.000069428          /* ORDREW    */ V10= -0.000000105
/* ZDDGADAM  */ V11=    1.067092          /* ZFFGOLIV  */ V12=   0.795470
/* ZDDGCOON  */ V13=    0.839120          /* ZFFGBROO  */ V14=   1.226209
/* ZDDSPRU   */ V15=    0.559862          /* ZFFKNOX   */ V16=   0.542533
/* ZCGBELK   */ V17=    0.536253          /* ZCGNVIRG  */ V18=   0.773737
/* ZCGNCALI  */ V19=    0.878464          /* ZFFGARC   */ V20=   0.544060
/* ZCGLEAH   */ V21=    0.491105          /* ZAVMCONV  */ V22=   1.343811
/* ZLPHIWO_  */ V23=    0.598014          /* ZLHATARA  */ V24=   0.454665
/* ZCGNTRUX  */ V25=    0.739923          /* ZDDGKIDD  */ V26=   0.514966
/* ZCGTICO   */ V27=    0.139855          /* ZCGNLONG  */ V28=   0.982165
/* ZCVFORR   */ V29=    0.555256          /* ZAGFFLAG  */ V30=   0.643230
/* ZPHMPEGA  */ V31=    0.126956          /* ZFFBRON   */ V32=   0.547593
/* ZAOESACR  */ V33=    0.265914          /* ZMCMAVEN  */ V34=   0.136813
/* ZCGNBAIN  */ V35=    0.586647          /* ZDDHULL   */ V36=   0.331609
/* ZAORWICH  */ V37=    0.234041          /* ZLSDWHID  */ V38=   0.345525
/* ZCVKITT   */ V39=    0.435289          /* ZMSOAGGR  */ V40=   0.096773
/* ZLPDAUST  */ V41=    0.248255          /* ZCVNENTE  */ V42=   0.771852
/* ZLSTNEWP  */ V43=    0.180570          /* ZLPDRALE  */ V44=   0.676457
/* ZCVNNIMI  */ V45=    0.235280 ;

MODEL NEWWEAP = EXP( V1 + TOP3PR * V2 + APARTPS * V3 + ALABPS * V4 + TSLDPE * V5
+ LGLDPE * V6 + DEPOTM1 * V7 + MOD * V8 + HRSUWM1 * V9 + ORDREW * V10 +
ZDDGADAM * V11 + ZFFGOLIV * V12 + ZDDGCOON * V13 + ZFFGBROO * V14 + ZDDSPRU *
V15 + ZFFKNOX * V16 + ZCGBELK * V17 + ZCGNVIRG * V18 + ZCGNCALI * V19 + ZFFGARC *
V20 + ZCGLEAH * V21 + ZAVMCONV * V22 + ZLPHIWO_ * V23 + ZLHATARA * V24 +
```

```
ZCGNTRUX * V25 + ZDDGKIDD * V26 + ZCGTICO * V27 + ZCGNLONG * V28 + ZCVFORR *
V29 + ZAGFFLAG * V30 + ZPHMPEGA * V31 + ZFFBRON * V32 + ZAOESACR * V33 +
ZMCMAVEN * V34 + ZCGNBAIN * V35 + ZDDHULL * V36 + ZAORWICH * V37 + ZLSDWHID *
V38 + ZCVKITT * V39 + ZMSOAGGR * V40 + ZLPDAUST * V41 + ZCVNENTE * V42 +
ZLSTNEWP * V43 + ZLPDRALE * V44 + ZCVNNIMI * V45 );

/* NWEAP HOLDS PREDICTED VALUE AND RESIDUAL */
OUTPUT OUT=NWEAP P=PNWEAP R=RESID;
PROC SORT; BY YEAR;
/*  PROC PLOT; PLOT RESID*HULL; BY YEAR;
PROC UNIVARIATE PLOT NORMAL;
VAR RESID;                    */
DATA NWEAP;
SET NWEAP;
IF PNWEAP = . THEN DELETE;
KEEP NEWWEAP PNWEAP DAYSINC5 TYPE HULL YEAR POTF;

/* SUMMARY BY YEAR OF NEWWEAP AND PNWEAP */
PROC SUMMARY NWAY DATA=NWEAP;
CLASS YEAR;
VAR NEWWEAP PNWEAP;

/* OUTPUT GOES INTO C3--MEAN OF NEWWEAP AND PNWEAP BY YEAR. PRINTS C3 */
OUTPUT OUT=C3 MEAN=NEWWEAP PNWEAP;
/*   PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, NEWWEAP';
PROC PLOT;
PLOT PNWEAP*YEAR='P'
NEWWEAP*YEAR='A'/OVERLAY;             */

/* SAVE UNDER NWEAP FILE */
DATA RESLTZ.NWEAP; SET NWEAP;

/* CREATES SET PD WITH LENGTH OF FOUR COLUMNS (TYPE,HULL,YEAR,NOPDAY),
  READS IN EXTERNAL DATA SET PDAT (STOPS READ IF <8 VARS IN DATA SET),
  AND SORTS BY TYPE,HULL,YEAR */

DATA PD;
LENGTH TYPE $4;
INFILE PDAT STOPOVER;
INPUT TYPE $ HULL YEAR P N M C NOPDAY;
KEEP TYPE HULL YEAR NOPDAY;
PROC SORT; BY TYPE HULL YEAR;

/* CREATE AND SORT THE SET NHULL */
DATA NHULL;
SET RESLTZ.NHULL;
KEEP TYPE HULL YEAR PNHULL NEWHULL POTF ;
PROC SORT; BY TYPE HULL YEAR;

/* CREATE AND SORT THE SET NCOMM */
DATA NCOMM;
```

```
SET RESLTZ.NCOMM;
KEEP TYPE HULL YEAR PNCOMM NEWCOMM POTF ;
PROC SORT; BY TYPE HULL YEAR;

/* CREATE AND SORT THE SET NWEAP */
DATA NWEAP;
SET RESLTZ.NWEAP;
KEEP TYPE HULL YEAR PNWEAP NEWWEAP POTF ;
PROC SORT; BY TYPE HULL YEAR;

/* CREATE AND SORT THE SET MTTCH */
DATA MTTCH;
SET RESLTZ.MTTCH;
KEEP TYPE HULL YEAR PMTTCH MTTCH POTF ;
PROC SORT; BY TYPE HULL YEAR;

/* CREATE AND SORT THE SET MTTCC */
DATA MTTCC;
SET RESLTZ.MTTCC;
KEEP TYPE HULL YEAR PMTTCC MTTCC POTF ;
PROC SORT; BY TYPE HULL YEAR;

/* CREATE THE AND SORT THE SET MTTCW */
DATA MTTCW;
SET RESLTZ.MTTCW;
KEEP TYPE HULL YEAR PMTTCW MTTCW POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA PD ; SET PD ;
PROC SUMMARY NWAY ; VAR NOPDAY ; CLASS YEAR ;
OUTPUT OUT=OPDAYS SUM=TOTALOP ;

/* CREATE A SAS DATA SET NAMED 'WHOLE' CONSISTING OF THE VARIABLES
  LISTED IN THE MERGE AND SORTED BY TYPE,HULL,YEAR */
DATA WHOLE;
MERGE NHULL NCOMM NWEAP MTTCH MTTCC MTTCW PD;
BY TYPE HULL YEAR;
IF PMTTCW=. THEN DELETE;
IF PMTTCH=. THEN DELETE;
IF PMTTCC=. THEN DELETE;

PROC SORT ; BY YEAR ;
DATA WHOLE ; MERGE OPDAYS WHOLE ; BY YEAR ;

/* CALCULATE THE FOLLOWING FOUR VARIABLES */
NEWCAS = NEWCOMM + NEWHULL + NEWWEAP;
PNEWCAS = PNCOMM + PNHULL + PNWEAP;
MTTC = (NEWHULL/NEWCAS)*MTTCH + (NEWWEAP/NEWCAS)*MTTCW +
   (NEWCOMM/NEWCAS)*MTTCC;
PMTTC = (PNHULL/PNEWCAS)*PMTTCH + (PNWEAP/PNEWCAS)*PMTTCW +
   (PNCOMM/PNEWCAS)*PMTTCC;
```

```
PPOTF = EXP(-.0024*
(PNHULL*PMTTCH+PNCOMM*PMTTCC+PNWEAP*PMTTCW));
PPOTF = PPOTF * 100 ;

WPPOTF = PPOTF*NOPDAY/TOTALOP ;
WPOTF = POTF * NOPDAY / TOTALOP ;

POTFDIF = PPOTF - POTF;
WPOTFDIF = WPPOTF - WPOTF ;
MTTCDIF = PMTTC - MTTC;
NCASDIF = PNEWCAS - NEWCAS;

MTTCHDIF = PMTTCH - MTTCH;
MTTCCDIF = PMTTCC - MTTCC;
MTTCWDIF = PMTTCW - MTTCW;
NHULLDIF = PNHULL - NEWHULL;
NCOMMDIF = PNCOMM - NEWCOMM;
NWEAPDIF = PNWEAP - NEWWEAP;

POTFSQR = POTFDIF**2;
WPOTFSQR = WPOTFDIF**2;
MTTCSQR = MTTCDIF**2;
NCASSQR = NCASDIF**2;

MTTCHSQR = MTTCHDIF**2;
MTTCCSQR = MTTCCDIF**2;
MTTCWSQR = MTTCWDIF**2;
NHULLSQR = NHULLDIF**2;
NCOMMSQR = NCOMMDIF**2;
NWEAPSQR = NWEAPDIF**2;

IF POTF NE 0 THEN MREPOTF = ABS(POTFDIF) / ABS(POTF) ;
IF WPOTF NE 0 THEN MREWPOTF = ABS(WPOTFDIF) / ABS(WPOTF) ;
IF MTTC NE 0 THEN MREMTTC = ABS(MTTCDIF) / ABS(MTTC) ;
IF NEWCAS NE 0 THEN MRENCAS = ABS(NCASDIF) / ABS(NEWCAS) ;
IF MTTCH NE 0 THEN MREMTTCH = ABS(MTTCHDIF) / ABS(MTTCH) ;
IF MTTCC NE 0 THEN MREMTTCC = ABS(MTTCCDIF) / ABS(MTTCC) ;
IF MTTCW NE 0 THEN MREMTTCW = ABS(MTTCWDIF) / ABS(MTTCW) ;
IF NEWHULL NE 0 THEN MRENHULL = ABS(NHULLDIF) / ABS(NEWHULL) ;
IF NEWCOMM NE 0 THEN MRENCOMM = ABS(NCOMMDIF) / ABS(NEWCOMM) ;
IF NEWWEAP NE 0 THEN MRENWEAP = ABS(NWEAPDIF) / ABS(NEWWEAP) ;

DATA WHOLE ; SET WHOLE ;
PROC SORT; BY YEAR;

PROC SUMMARY PRINT MEAN ; WEIGHT NOPDAY ;
VAR POTF PPOTF ;
CLASS YEAR ;
OUTPUT OUT=PREDPOTF MEAN=MEANPOTF;
TITLE 'PROC SUMMARY OF POTF VALUES USING PRINT OPTION' ;
```

```
PROC PRINT DATA=PREDPOTF ;
TITLE 'PROC SUMMARY OF POTF VALUES USING PROC PRINT' ;

DATA WHOLE ; SET WHOLE ;
PROC MEANS SUM MEAN ;
VAR POTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR
  MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH MTTCHSQR
MREMTTCH
  MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW MTTCWSQR MREMTTCW
  NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM PNCOMM NCOMMSQR
MRENCOMM
  NEWWEAP PNWEAP NWEAPSQR MRENWEAP MREPOTF ;
BY YEAR;
TITLE 'PROC MEANS OF POTF VALUES BY YEAR' ;

PROC MEANS SUM MEAN ;
VAR POTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR
  MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH MTTCHSQR
MREMTTCH
  MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW MTTCWSQR MREMTTCW
  NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM PNCOMM NCOMMSQR
MRENCOMM
  NEWWEAP PNWEAP NWEAPSQR MRENWEAP MREPOTF ;
TITLE 'PROC MEANS OF POTF VALUES OVERALL' ;
```

APPENDIX B. CODE FOR SIM FULL MODEL RUN

Appendix B contains the SAS code that was used to perform the full model run for the SIM.

•

```
//SIM1C   JOB USER=S6402,CLASS=C
//  EXEC SAS
//WORK DD UNIT=SYSDA,SPACE=(CYL,(10,10))
//PDAT DD UNIT=SYSDA,DISP=SHR,DSN=MSS.S6402.FY92.POTF
//REG2 DD DISP=SHR,DSN=MSS.S6402.MATHTECH
//RESLTZ DD DSN=MSS.S6402.FY91.MODEL.PREDACTS,
// DISP=(OLD,KEEP),UNIT=SYSDA,
// SPACE=(TRK,(10,10),RLSE)
//SYSIN DD *

OPTIONS LS=132;
 DATA STOCKF1;
 /*      INFILE CARDS STOPOVER;              */
 INPUT YEAR ACWT RFIT OPNDEF;
 CARDS;
 82  563  3334.9  .7301
 83  514 4615.1   .7577
 84 498 4968.1    .7802
 85 480 5328.9    .8032
 86 461 4887.5    .8312
 87 423 4538.5    .8610
 88 396 4333.3    .9005
 89 384 3665.3    .9348
 90 346 3472.2    .9679
 91 293 3909.4    1.00
 92 284  2986.4 1.0326
 DATA STOCKF;
 /*     INFILE CARDS STOPOVER;               */
 INPUT YEAR RFI DUE NRFI TOTSTOCK LTJ SMA;
 CARDS;
82    1106    1169    494    2769    2109    73.3
83    1642    1378    646    3666    2883    75.1
84    2369    1680    862    4911    4005    77.3
85    2693    2331   1012    6036    4540    77
86    3019    2224    946    6189    4257    81.3
87    3363    2339    960    6662    4794    84.2
88    3484    1922    945    6351    5272    85.1
89    3210    1382    968    5560    4718    87.1
90    3018     999   1006    5023    4483    87.5
91    3372     733   1276    5381    4798    89
92    3136      .       .       .       .       .
 ;
```

```
PROC SORT; BY YEAR;
DATA R2;
SET REG2.MASTER92;
IF YEAR > 81 ;
/*                IF YEAR GT 90;          */
RENAME APARTPS=AGPARPS;
RENAME ALABPS=AGLABPS;

/*              IF YEAR > 80;            */
IF NEWCAS = 0 THEN DO;
NEWHULL = 0;
NEWCOMM = 0;
NEWWEAP = 0;
END;
IF NEWCAS = . THEN DO;
NEWHULL = .;
NEWCOMM = .;
NEWWEAP = . ;
END;
IF HRSUWM1 = . THEN HRSUWM1 = 0;
IF OVHLM1=. THEN OVHLM1 = 0;
IF FMPM1=. THEN FMPM1=0;
IF SRAM1=. THEN SRAM1=0;
DEPOTM1 = OVHLM1 + FMPM1 + SRAM1;
DEPOT = OVHL+FMP+SRA;
IF TOP3PR = . THEN TOP3PR = 0;
PROC SORT; BY YEAR;

DATA R2; MERGE STOCKF STOCKF1 R2; BY YEAR;
DATA R2 ; SET R2 ; IF YEAR GT 81 ;
DATA R2 ; SET R2 ;
PROC FREQ ; TABLES YEAR ;
TITLE 'YEARS IN NEW DATABASE';

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4   /* MTTC HULL */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP */ V116 =   4.46046229        /* TOP3PR    */ V117 =  -2.19650394
/* ZLSTNEWP  */ V119 =   0.47216221       /* ZASRPIGE  */ V120 =   0.76232903
/* ZFFKNOX   */ V121 =  -0.21861384       /* ZFFGOLIV  */ V122 =  -0.15982790
/* AGLABPS   */ V123 =  -0.10953821       /* ZMSOAGGR  */ V124 =   0.34346873
/* ZASEMOR   */ V125 =   0.11558510       /* ZARSDIVE  */ V127 =   0.56124419
/* ZASFULT   */ V128 =   0.93305894       /* ZLSDTHOM  */ V129 =   0.52566102
/* ZASRCHAN  */ V130 =   0.44462777       /* ZADSAMU   */ V131 =   0.78392709
/* ZCVNNIMI  */ V133 =   0.26399954       /* ZARVULC   */ V134 =   0.24431511
/* ZAOJUMB   */ V135 =   0.63343006       /* ZLKACHAR  */ V136 =   0.36490837
/* ZCGNBAIN  */ V137 =   0.25530422       /* ZATSEDEN  */ V138 =   0.63089701
/* ZPHMPEGA  */ V141 =   0.35196968       /* ZLHATARA  */ V142 =   0.28443246
/* ZDDGCOON  */ V143 =   0.19178388       /* ZCGNVIRG  */ V144 =   0.41089695
```

```
/* ZADYELL   */ V145 =   0.34173211          /* ZCVMIDW   */ V146 =   0.19938902
/* ZAOCIMA   */ V147 =  -0.42066962          /* ZCVNENTE  */ V148 =   0.72158845
/* RFI       */ V201 =  -0.0001237 ;

MODEL MTTCH = EXP( V116 + TOP3PR * V117 + ZLSTNEWP * V119 + ZASRPIGE * V120 +
ZFFKNOX * V121 + ZFFGOLIV * V122 + AGLABPS * V123 + ZMSOAGGR * V124 + ZASEMOR *
V125 + ZARSDIVE * V127 + ZASFULT * V128 + ZLSDTHOM * V129 + ZASRCHAN * V130 +
ZADSAMU * V131 + ZCVNNIMI * V133 + ZARVULC * V134 + ZAOJUMB * V135 + ZLKACHAR *
V136 + ZCGNBAIN * V137 + ZATSEDEN * V138 + ZPHMPEGA * V141 + ZLHATARA * V142 +
ZDDGCOON * V143 + ZCGNVIRG * V144 + ZADYELL * V145 + ZCVMIDW * V146 + ZAOCIMA
* V147 + ZCVNENTE * V148 + RFI * V201 );
OUTPUT OUT=MTTCH P=PMTTCH R=RESID;
DATA MTTCH;
SET MTTCH;
IF PMTTCH = . THEN DELETE;
KEEP MTTCH PMTTCH DAYSINC5 TYPE HULL YEAR POTF;
PROC SUMMARY NWAY DATA=MTTCH;
CLASS YEAR;
VAR MTTCH PMTTCH;
OUTPUT OUT=C4 MEAN=MTTCH PMTTCH;
/* PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, MTTC HULL';
PROC PLOT;
PLOT PMTTCH*YEAR='P'
MTTCH*YEAR='A'/OVERLAY;      */
DATA RESLTZ.MTTCH; SET MTTCH;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4 /* MTTC C-CUBED */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP */ V149 =   4.64841456           /* TOP3PR    */ V150 =  -2.73839887
/* AGLABPS   */ V151 =  -0.12383180          /* ZADSAMU   */ V152 =   0.80933424
/* AGPARPS   */ V153 =  -0.21962747          /* ZLSTNEWP  */ V154 =  -0.30970380
/* ZDDGADAM  */ V155 =   0.27476343          /* ZLCCBLUE  */ V156 =   0.07571016
/* ZCGLEAH   */ V157 =   0.40789611          /* ZFFKNOX   */ V158 =   0.18746126
/* ZMSOAGGR  */ V159 =   0.21674706          /* ZFFGOLIV  */ V160 =   0.17147944
/* ZLPHIWO_  */ V161 =   0.48573885          /* ZLHATARA  */ V162 =   0.51917596
/* ZDDSPRU   */ V163 =   0.23987743          /* ZFFGARC   */ V164 =   0.20071428
/* ZFFGBROO  */ V165 =   0.38847571          /* ZPHMPEGA  */ V166 =   0.53315337
/* ZCVNENTE  */ V167 =   0.75996708          /* ZAGFFLAG  */ V170 =   0.44494621
/* RFI       */ V202 =  -0.0001143 ;

MODEL MTTCC = EXP( V149 + TOP3PR * V150 + AGLABPS * V151 + ZADSAMU * V152 +
AGPARPS * V153 + ZLSTNEWP * V154 + ZDDGADAM * V155 + ZLCCBLUE * V156 + ZCGLEAH
* V157 + ZFFKNOX * V158 + ZMSOAGGR * V159 + ZFFGOLIV * V160 + ZLPHIWO_ * V161 +
ZLHATARA * V162 + ZDDSPRU * V163 + ZFFGARC * V164 + ZFFGBROO * V165 + ZPHMPEGA
* V166 + ZCVNENTE * V167 + ZAGFFLAG * V170 + RFI * V202 );
OUTPUT OUT=MTTCC P=PMTTCC R=RESID;
DATA MTTCC;
SET MTTCC;
```

```
IF PMTTCC = . THEN DELETE;
KEEP MTTCC PMTTCC DAYSINC5 TYPE HULL YEAR POTF;
PROC SUMMARY NWAY DATA=MTTCC;
CLASS YEAR;
VAR MTTCC PMTTCC;
OUTPUT OUT=C5 MEAN=MTTCC PMTTCC;
/*   PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, MTTC COMM';
PROC PLOT;
PLOT PMTTCC*YEAR='P'
MTTCC*YEAR='A'/OVERLAY;          */
DATA RESLTZ.MTTCC; SET MTTCC;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4    /*  MTTC WEAPONS */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP */  V171 =    5.10623019          /* TOP3PR     */ V172 =  -3.73457296
/* ZMSOAGGR   */ V173 =    0.55910201         /* AGPARPS    */ V174 =  -0.41512729
/* ZLSTNEWP   */ V175 =  -0.27322387          /* ZCGBELK    */ V176 =   0.04443564
/* ZCGNVIRG   */ V177 =   0.40434840          /* ZLPDAUST   */ V179 =  -0.33102217
/* ZLSDTHOM   */ V180 =  -0.55048267          /* AGLABPS    */ V181 =  -0.08089881
/* ZLSDANCH   */ V182 =  -0.02429785          /* ZLCCBLUE   */ V183 =   0.28056646
/* ZFFKNOX    */ V184 =  -0.18554393          /* RFI        */ V203 =  -0.0000604 ;

MODEL MTTCW = EXP( V171 + TOP3PR * V172 + ZMSOAGGR * V173 + AGPARPS * V174 +
ZLSTNEWP * V175 + ZCGBELK * V176 + ZCGNVIRG * V177 + ZLPDAUST * V179 + ZLSDTHOM
* V180 + AGLABPS * V181 + ZLSDANCH * V182 + ZLCCBLUE * V183 + ZFFKNOX * V184 + RFI
* V203 );
OUTPUT OUT=MTTCW P=PMTTCW R=RESID;
DATA MTTCW;
SET MTTCW;
IF PMTTCW = . THEN DELETE;
KEEP MTTCW PMTTCW DAYSINC5 TYPE HULL YEAR POTF ;
PROC SUMMARY NWAY DATA=MTTCW;
CLASS YEAR;
VAR MTTCW PMTTCW;
OUTPUT OUT=C6 MEAN=MTTCW PMTTCW;
/*   PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, MTTC WEAPONS';
PROC PLOT;
PLOT PMTTCW*YEAR='P'
MTTCW*YEAR='A'/OVERLAY;          */
DATA RESLTZ.MTTCW; SET MTTCW;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4      /* HULL CASREPS */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEP */ V83 =   2.75813056            /* TOP3PR     */ V84 =            1777
/* ZADDIXI    */ V85 =   0.28992746           /* ZAESURI    */ V86 =            7827
```

```
/* ZAOCIMA   */ V87 =  1.44825248          /* ZAOJUMB   */ V88 =  1.92287008
/* ZARSDIVE  */ V89 =  1.17141307          /* ZASEMOR   */ V90 = -1.50248281
/* ZASFULT   */ V91 = -1.27670531          /* ZASSIMO   */ V92 = -3.09795804
/* ZCGNCALI  */ V93 = -1.89933461          /* ZDDGADAM  */ V94 = -0.25251545
/* ZFFBRON   */ V95 =  1.08535584          /* ZFFGARC   */ V96 =  1.15789638
/* ZFFGBROO  */ V97 =  0.96555031          /* ZFFKNOX   */ V98 =  0.90963405
/* ZLHATARA  */ V99 =  1.33789277          /* ZLKACHAR  */ V100 =  1.30999872
/* ZLPDAUST  */ V101 =  1.06780684         /* ZLPDRALE  */ V102 =  1.31560997
/* ZLPHIWO_  */ V103 =  1.98978377         /* ZLSDANCH  */ V104 =  1.79762251
/* ZLSDTHOM  */ V105 =  1.97248932         /* ZLSTNEWP  */ V106 =  0.91257187
/* ZMSOAGGR  */ V107 = -0.02338811         /* ZPHMPEGA  */ V108 =  1.85079941
/* AGPARPS   */ V109 = -0.82627749         /* AGLABPS   */ V110 =  0.10861735
/* TSLDPE    */ V111 =  0.000317295        /* DEPOTM1   */ V112 = -4.94064E-09
/* MOD       */ V113 = -0.34574539         /* HRSUWM1   */ V114 = -0.000178714
/* ORDREW    */ V115 = -.0000013064        /* ACWT      */ V204 =  0.002775 ;

MODEL NEWHULL = EXP( V83 + TOP3PR * V84 + ZADDIXI * V85 + ZAESURI * V86 +
ZAOCIMA * V87 + ZAOJUMB * V88 + ZARSDIVE * V89 + ZASEMOR * V90 + ZASFULT * V91 +
ZASSIMO * V92 + ZCGNCALI * V93 + ZDDGADAM * V94 + ZFFBRON * V95 + ZFFGARC * V96
+ ZFFGBROO * V97 + ZFFKNOX * V98 + ZLHATARA * V99 + ZLKACHAR * V100 + ZLPDAUST
* V101 + ZLPDRALE * V102 + ZLPHIWO_ * V103 + ZLSDANCH * V104 + ZLSDTHOM * V105 +
ZLSTNEWP * V106 + ZMSOAGGR * V107 + ZPHMPEGA * V108 + AGPARPS * V109 + AGLABPS
* V110 + TSLDPE * V111 + DEPOTM1 * V112 + MOD * V113 + HRSUWM1 * V114 + ORDREW *
V115 + ACWT * V204);
OUTPUT OUT=NHULL P=PNHULL R=RESID;
DATA NHULL;
SET NHULL;
IF PNHULL = . THEN DELETE;
KEEP NEWHULL PNHULL DAYSINC5 TYPE HULL YEAR POTF ;
PROC SUMMARY NWAY DATA=NHULL;
CLASS YEAR;
VAR NEWHULL PNHULL;
OUTPUT OUT=C1 MEAN=NEWHULL PNHULL
/*    PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, NEWHULL';
PROC PLOT;
PLOT PNHULL*YEAR='P'
NEWHULL*YEAR='A'/OVERLAY;                    */
DATA RESLTZ.NHULL; SET NHULL;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
   FACTOR OF .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4  /* C-CUBED CASREPS */
CONVERGE = .001 DATA=R2 EFORMAT;
PARMS
/* INTERCEPT  */ V1 =  3.30567561          /* TOP3PR    */ V2 =  0.83745806
/* AGPARPS    */ V3 = -0.05101614          /* AGLABPS   */ V4 = -0.17718335
/* LGLDPE     */ V5 =  0.00000459          /* MOD       */ V6 = -0.07588553
/* HRSUWM1    */ V7 = -0.00004020          /* ORDREW    */ V8 = -0.00000008
/* ZAFSMARS   */ V9 = -0.22595613          /* ZAOESACR  */ V10 =  0.43679169
/* ZARSDIVE   */ V11 = -0.36700569         /* ZASHUNL   */ V12 = -0.58220291
/* ZASRCHAN   */ V13 = -0.47455258         /* ZASRPIGE  */ V14 = -0.72419324
```

```
/* ZATFCHER    */ V15 =   1.52349214        /* ZCGBELK     */ V16 =   0.33675317
/* ZCGLEAH     */ V17 =   0.40633604        /* ZCGNLONG    */ V18 =   0.48687014
/* ZCGNVIRG    */ V19 =   0.38308346        /* ZCVJFK      */ V20 =   1.04378799
/* ZCVKITT     */ V21 =   0.33441533        /* ZCVNENTE    */ V22 =   0.91088399
/* ZDDGADAM    */ V23 =   0.35133388        /* ZDDGCOON    */ V24 =   0.43009956
/* ZFFBRON     */ V25 =   0.88695495        /* ZFFGARC     */ V26 =   0.34685514
/* ZFFGBROO    */ V27 =   0.74942534        /* ZFFGOLIV    */ V28 =   0.41380544
/* ZFFKNOX     */ V29 =   0.37687609        /* ZLCCBLUE    */ V30 =   0.43225974
/* ZLHATARA    */ V31 =   0.45721451        /* ZLKACHAR    */ V32 =   -0.39242086
/* ZMSOAGGR    */ V33 =   0.59618050        /* ACWT        */ V205 =  0.00482 ;

MODEL NEWCOMM = EXP( V1 + TOP3PR * V2 + AGPARPS * V3 + AGLABPS * V4 + LGLDPE *
V5 + MOD * V6 + HRSUWM1 * V7 + ORDREW * V8 + ZAFSMARS * V9 + ZAOESACR * V10 +
ZARSDIVE * V11 + ZASHUNL * V12 + ZASRCHAN * V13 + ZASRPIGE * V14 + ZATFCHER *
V15 + ZCGBELK * V16 + ZCGLEAH * V17 + ZCGNLONG * V18 + ZCGNVIRG * V19 + ZCVJFK *
V20 + ZCVKITT * V21 + ZCVNENTE * V22 + ZDDGADAM * V23 + ZDDGCOON * V24 +
ZFFBRON * V25 + ZFFGARC * V26 + ZFFGBROO * V27 + ZFFGOLIV * V28 + ZFFKNOX * V29 +
ZLCCBLUE * V30 + ZLHATARA * V31 + ZLKACHAR * V32 + ZMSOAGGR * V33 + ACWT *
V205 );
OUTPUT OUT=NCOMM P=PNCOMM R=RESID;
DATA NCOMM;
SET NCOMM;
IF PNCOMM = . THEN DELETE;
KEEP NEWCOMM PNCOMM DAYSINC5 TYPE HULL YEAR POTF ;
PROC SUMMARY NWAY DATA=NCOMM;
CLASS YEAR;
VAR NEWCOMM PNCOMM;
OUTPUT OUT=C2 MEAN=NEWCOMM PNCOMM;
/*   PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, NEWCOMM';
PROC PLOT;
PLOT PNCOMM*YEAR='P'
NEWCOMM*YEAR='A'/OVERLAY;                 */
DATA RESLTZ.NCOMM; SET NCOMM;

/* PERFORM NONLINEAR REGRESSION STOPPING AT MAX 50 ITERATIONS AND
  USING CONVERGENCE CRITERIA OF .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4  /* WEAPONS CASREPS */
CONVERGE = .001 DATA=R2 EFORMAT;

PARMS
 /* INTERCEPT */  V1 =  0.75234527          /* AGPARPS   */  V2 =  -0.01071655
 /* LGLDPE    */  V3 =  0.00037997          /* TSLDPE    */  V4 =  0.00008981
 /* DEPOTM1   */  V5 =  -0.00000001         /* MOD       */  V6 =  -0.11496187
 /* HRSUWM1   */  V7 =  -0.00006158         /* ORDREW    */  V8 =  -0.00000012
 /* ZAGFFLAG  */  V9 =  0.39917989          /* ZAVMCONV  */  V10=  1.18612111
 /* ZCGBELK   */  V11=  0.32992413          /* ZCGLEAH   */  V12=  0.32900069
 /* ZCGNCALI  */  V13=  0.68932389          /* ZCGNLONG  */  V14=  0.65876400
 /* ZCGNTRUX  */  V15=  0.53760652          /* ZCGNVIRG  */  V16=  0.66101776
 /* ZCVFORR   */  V17=  0.38655120          /* ZCVNENTE  */  V18=  0.46557935
 /* ZDDGADAM  */  V19=  0.84715520          /* ZDDGCOON  */  V20=  0.58886617
 /* ZDDSPRU   */  V21=  0.33678192          /* ZFFGARC   */  V22=  0.27197095
```

```
/* ZFFGBROO   */  V23=  0.98497943          /* ZFFGOLIV   */  V24=  0.54119666
/* ZFFKNOX    */  V25=  0.29874018          /* ZLCCBLUE   */  V26=  -0.58288198
/* ZLPHIWO_   */  V27=  0.32731611          /* ZLSDWHID   */  V28=  0.50492408
/* ACWT       */  V206 = 0.0028 ;

MODEL NEWWEAP = EXP( V1 + AGPARPS * V2 + LGLDPE * V3 + TSLDPE * V4 + DEPOTM1 *
V5 +*MOD * V6 + HRSUWM1 * V7 + ORDREW * V8 + ZAGFFLAG * V9 + ZAVMCONV * V10 +
ZCGBELK * V11 + ZCGLEAH * V12 + ZCGNCALI * V13 + ZCGNLONG * V14 + ZCGNTRUX *
V15 + ZCGNVIRG * V16 + ZCVFORR * V17 + ZCVNENTE * V18 + ZDDGADAM * V19 +
ZDDGCOON * V20 + ZDDSPRU * V21 + ZFFGARC * V22 + ZFFGBROO * V23 + ZFFGOLIV * V24
+ ZFFKNOX * V25 + ZLCCBLUE * V26 + ZLPHIWO_ * V27 + ZLSDWHID * V28 + ACWT * V206
);
OUTPUT OUT=NWEAP P=PNWEAP R=RESID;
DATA NWEAP;
SET NWEAP;
IF PNWEAP = . THEN DELETE;
KEEP NEWWEAP PNWEAP DAYSINC5 TYPE HULL YEAR POTF ;
PROC SUMMARY NWAY DATA=NWEAP;
CLASS YEAR;
VAR NEWWEAP PNWEAP;
OUTPUT OUT=C3 MEAN=NEWWEAP PNWEAP;
/* PROC PRINT;TITLE 'AGGREGATE PREDICTED AND ACTUALS, NEWWEAP';
PROC PLOT;
PLOT PNWEAP*YEAR='P'
NEWWEAP*YEAR='A'/OVERLAY;              */
DATA RESLTZ.NWEAP; SET NWEAP;

DATA PD;
LENGTH TYPE $4;
INFILE PDAT STOPOVER;
INPUT TYPE $ HULL YEAR P N M C NOPDAY;
KEEP TYPE HULL YEAR NOPDAY;
PROC SORT; BY TYPE HULL YEAR;

DATA NHULL;
SFT RESLTZ.NHULL;
KEEP TYPE HULL YEAR PNHULL NEWHULL POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA NCOMM;
SET RESLTZ.NCOMM;
KEEP TYPE HULL YEAR PNCOMM NEWCOMM POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA NWEAP;
SET RESLTZ.NWEAP;
KEEP TYPE HULL YEAR PNWEAP NEWWEAP POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA MTTCH;
SET RESLTZ.MTTCH;
```

```
KEEP TYPE HULL YEAR PMTTCH MTTCH POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA MTTCC;
SET RESLTZ.MTTCC;
KEEP TYPE HULL YEAR PMTTCC MTTCC POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA MTTCW;
SET RESLTZ.MTTCW;
KEEP TYPE HULL YEAR PMTTCW MTTCW POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA PD; SET PD;
PROC SUMMARY NWAY; VAR NOPDAY; CLASS YEAR;
OUTPUT OUT=OPDAYS SUM=TOTALOP;

DATA WHOLE;
MERGE NHULL NCOMM NWEAP MTTCH MTTCC MTTCW PD;
BY TYPE HULL YEAR;
IF PMTTCW=. THEN DELETE;
IF PMTTCH=. THEN DELETE;
IF PMTTCC=. THEN DELETE;

PROC SORT ; BY YEAR ;
DATA WHOLE ; MERGE OPDAYS WHOLE ; BY YEAR ;

NEWCAS = NEWCOMM + NEWHULL + NEWWEAP;
PNEWCAS = PNCOMM + PNHULL + PNWEAP;
MTTC = (NEWHULL/NEWCAS)*MTTCH + (NEWWEAP/NEWCAS)*MTTCW +
   (NEWCOMM/NEWCAS)*MTTCC;
PMTTC = (PNHULL/PNEWCAS)*PMTTCH + (PNWEAP/PNEWCAS)*PMTTCW +
   (PNCOMM/PNEWCAS)*PMTTCC;
PPOTF = EXP(-.0024*
(PNHULL*PMTTCH+PNCOMM*PMTTCC+PNWEAP*PMTTCW));
PPOTF = PPOTF * 100 ;

WPPOTF = PPOTF*NOPDAY/TOTALOP ;
WPOTF = POTF * NOPDAY / TOTALOP ;

POTFDIF = PPOTF - POTF;
WPOTFDIF = WPPOTF - WPOTF ;
MTTCDIF = PMTTC - MTTC;
NCASDIF = PNEWCAS - NEWCAS;

MTTCHDIF = PMTTCH - MTTCH;
MTTCCDIF = PMTTCC - MTTCC;
MTTCWDIF = PMTTCW - MTTCW;
NHULLDIF = PNHULL - NEWHULL;
NCOMMDIF = PNCOMM - NEWCOMM;
NWEAPDIF = PNWEAP - NEWWEAP;
```

```
POTFSQR = POTFDIF**2;
WPOTFSQR = WPOTFDIF**2;
MTTCSQR = MTTCDIF**2;
NCASSQR = NCASDIF**2;

MTTCHSQR = MTTCHDIF**2;
MTTCCSQR = MTTCCDIF**2;
MTTCWSQR = MTTCWDIF**2;
NHULLSQR = NHULLDIF**2;
NCOMMSQR = NCOMMDIF**2;
NWEAPSQR = NWEAPDIF**2;


IF POTF NE 0 THEN MREPOTF = ABS(POTFDIF) / ABS(POTF) ;
IF WPOTF NE 0 THEN MREWPOTF = ABS(WPOTFDIF) / ABS(WPOTF) ;
IF MTTC NE 0 THEN MREMTTC = ABS(MTTCDIF) / ABS(MTTC) ;
IF NEWCAS NE 0 THEN MRENCAS = ABS(NCASDIF) / ABS(NEWCAS) ;
IF MTTCH NE 0 THEN MREMTTCH = ABS(MTTCHDIF) / ABS(MTTCH) ;
IF MTTCC NE 0 THEN MREMTTCC = ABS(MTTCCDIF) / ABS(MTTCC) ;
IF MTTCW NE 0 THEN MREMTTCW = ABS(MTTCWDIF) / ABS(MTTCW) ;
IF NEWHULL NE 0 THEN MRENHULL = ABS(NHULLDIF) / ABS(NEWHULL) ;
IF NEWCOMM NE 0 THEN MRENCOMM = ABS(NCOMMDIF) / ABS(NEWCOMM) ;
IF NEWWEAP NE 0 THEN MRENWEAP = ABS(NWEAPDIF) / ABS(NEWWEAP) ;

DATA WHOLE ; SET WHOLE ;
PROC SORT; BY YEAR;

PROC SUMMARY PRINT MEAN ; WEIGHT NOPDAY ;
VAR POTF PPOTF ;
CLASS YEAR ;
OUTPUT OUT=PREDPOTF MEAN=MEANPOTF;
TITLE 'PROC SUMMARY OF POTF VALUES USING PRINT OPTION' ;

PROC PRINT DATA=PREDPOTF ;
TITLE 'PROC SUMMARY OF POTF VALUES USING PROC PRINT' ;

DATA WHOLE ; SET WHOLE ;
PROC MEANS SUM MEAN ;
VAR POTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR
  MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH MTTCHSQR
MREMTTCH
  MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW MTTCWSQR MREMTTCW
  NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM PNCOMM NCOMMSQR
MRENCOMM
  NEWWEAP PNWEAP NWEAPSQR MRENWEAP MREPOTF ;
BY YEAR;
TITLE 'PROC MEANS OF POTF VALUES BY YEAR' ;

PROC MEANS SUM MEAN ;
```

```
VAR POTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR
  MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH MTTCHSQR
MREMTTCH
  MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW MTTCWSQR MREMTTCW
  NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM PNCOMM NCOMMSQR
MRENCOMM
  NEWWEAP PNWEAP NWEAPSQR MRENWEAP MREPOTF ;
TITLE 'PROC MEANS OF POTF VALUES OVERALL' ;
```

APPENDIX C. FITTED SRM

Appendix C contains the SAS output for the model fit of the SRM submodels from the full model run.

Non-Linear Least Squares Summary Statistics   Dependent Variable MTTC HULL

Source	DF	Sum of Squares	Mean Square
Regression	37	1472564.8551	39799.0501
Residual	3789	1583069.2998	417.8066
Uncorrected Total	3826	3055634.1549	
(Corrected Total)	3825	1775953.3457	

Model Coefficients for Dependent Variable MTTC HULL

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	4.96E+00	4.45E-01	4.08E+00	5.83E+00
V2	-3.30E-01	6.17E-01	-1.54E+00	8.79E-01
V3	-2.92E-01	5.68E-02	-4.04E-01	-1.81E-01
V4	-9.94E-02	2.99E-02	-1.58E-01	-4.09E-02
V5	3.65E-01	1.05E-01	1.59E-01	5.71E-01
V6	9.76E-01	1.81E+00	-2.57E+00	4.52E+00
V7	-4.93E-01	8.45E-02	-6.59E-01	-3.27E-01
V8	-4.38E-01	1.31E-01	-6.94E-01	-1.82E-01
V9	8.20E-01	1.93E-01	4.41E-01	1.20E+00
V10	8.14E-01	1.69E-01	4.83E-01	1.14E+00
V11	9.18E-01	2.22E-01	4.83E-01	1.35E+00
V12	4.81E-01	2.14E-01	6.22E-02	9.01E-01
V13	3.44E-01	1.50E-01	5.05E-02	6.38E-01
V14	5.75E-01	1.78E-01	2.26E-01	9.24E-01
V15	4.47E-01	3.99E+00	-7.38E+00	8.27E+00
V16	3.65E-01	1.82E-01	6.81E-03	7.22E-01
V17	3.44E-01	1.62E-01	2.57E-02	6.63E-01
V18	3.13E-01	2.24E-01	-1.25E-01	7.51E-01
V19	2.85E-01	2.30E-01	-1.66E-01	7.37E-01
V20	3.30E-01	2.17E-01	-9.47E-02	7.55E-01
V21	2.79E-01	1.64E-01	-4.29E-02	6.01E-01
V22	3.25E-01	2.29E-01	-1.23E-01	7.73E-01
V23	4.87E-01	2.58E-01	-1.74E-02	9.92E-01
V24	-4.19E-01	2.49E-01	-9.07E-01	6.91E-02
V25	-4.59E-01	2.32E-01	-9.15E-01	-3.45E-03
V26	-3.19E-01	1.73E-01	-6.58E-01	2.03E-02
V27	-7.69E-01	4.62E-01	-1.67E+00	1.36E-01
V28	-4.04E-01	2.39E-01	-8.71E-01	6.40E-02
V29	-2.02E-01	9.81E-02	-3.95E-01	-9.89E-03
V30	-5.14E-01	4.48E-01	-1.39E+00	3.65E-01
V31	4.91E-01	3.99E-01	-2.92E-01	1.27E+00
V32	-2.92E-01	2.23E-01	-7.29E-01	1.46E-01
V33	-5.69E-01	4.83E-01	-1.52E+00	3.79E-01
V34	-1.59E-01	1.49E-01	-4.51E-01	1.32E-01

V35	-2.76E-01	3.16E-01	-8.95E-01	3.43E-01
V36	-3.96E-01	4.30E-01	-1.24E+00	4.47E-01
V37	-2.60E-01	3.22E-01	-8.93E-01	3.72E-01

Non-Linear Least Squares Summary Statistics Dependent Variable MTTC COMM

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	31	720934.8	23255.96
Residual	3795	1578374	415.9087
Uncorrected Total	3826	2299308	
(Corrected Total)	3825	1693425	

Model Coefficients for Dependent Variable MTTC COMM

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	4.12E+00	2.59E-01	3.61E+00	4.63E+00
V2	-3.34E+00	1.62E+00	-6.51E+00	-1.72E-01
V3	-2.16E-01	7.16E-02	-3.56E-01	-7.56E-02
V4	-8.03E-02	2.62E-02	-1.32E-01	-2.90E-02
V5	8.65E-01	2.03E-01	4.67E-01	1.26E+00
V6	4.60E-01	2.25E-01	1.99E-02	9.01E-01
V7	-1.06E+00	1.20E+00	-3.41E+00	1.29E+00
V8	5.46E-01	2.26E-01	1.03E-01	9.89E-01
V9	1.78E-01	1.64E-01	-1.44E-01	5.00E-01
V10	4.10E-01	1.31E-01	1.52E-01	6.68E-01
V11	4.46E-01	3.66E-01	-2.71E-01	1.16E+00
V12	1.69E-01	2.48E-01	-3.18E-01	6.56E-01
V13	-9.23E-03	2.26E-01	-4.53E-01	4.34E-01
V14	1.76E-01	3.01E-01	-4.14E-01	7.65E-01
V15	7.54E-01	2.58E-01	2.49E-01	1.26E+00
V16	3.06E-01	1.04E-01	1.03E-01	5.10E-01
V17	3.33E-01	1.38E-01	6.23E-02	6.04E-01
V18	2.36E-01	4.07E-01	-5.62E-01	1.03E+00
V19	3.20E-01	9.07E-02	1.42E-01	4.98E-01
V20	4.43E-01	2.77E-01	-1.00E-01	9.87E-01
V21	2.66E-01	1.60E-01	-4.71E-02	5.79E-01
V22	4.58E-01	1.83E-01	9.89E-02	8.17E-01
V23	2.10E-01	1.04E-01	6.41E-03	4.13E-01
V24	2.47E-01	8.60E-02	7.81E-02	4.15E-01
V25	2.93E-01	2.35E-01	-1.67E-01	7.54E-01
V26	6.52E-01	1.29E-01	3.99E-01	9.05E-01
V27	4.52E-01	1.37E-01	1.84E-01	7.19E-01
V28	-3.25E-01	1.86E-01	-6.89E-01	3.97E-02
V29	4.67E-01	3.08E-01	-1.37E-01	1.07E+00
V30	2.11E-01	2.62E-01	-3.04E-01	7.25E-01
V31	1.98E-01	2.30E-01	-2.53E-01	6.49E-01

Non-Linear Least Squares Summary Statistics Dependent Variable MTTC WEAP

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	42	1012663	24111.02
Residual	3784	3241563	856.6498
Uncorrected Total	3826	4254226	
(Corrected Total)	3825	3452404	

Model Coefficients for Dependent Variable MTTC WEAP

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	4.49E+00	2.83E-01	3.93E+00	5.04E+00
V2	-1.68E-01	1.77E+00	-3.64E+00	3.31E+00
V3	-4.50E-01	9.50E-02	-6.37E-01	-2.64E-01
V4	-6.76E-02	2.83E-02	-1.23E-01	-1.20E-02
V5	-3.19E-01	3.9[illegible]E-01	-1.10E+00	4.61E-01
V6	3.18E-01	2.10E-01	-9.43E-02	7.30E-01
V7	2.23E-01	3.65E-01	-4.93E-01	9.40E-01
V8	6.62E-01	1.97E-01	2.76E-01	1.05E+00
V9	5.18E-01	1.74E-01	1.77E-01	8.59E-01
V10	5.00E-01	3.24E-01	-1.34E-01	1.13E+00
V11	-2.69E-01	8.50E-01	-1.94E+00	1.40E+00
V12	3.23E-01	1.89E-01	-4.69E-02	6.93E-01
V13	4.90E-01	1.60E-01	1.76E-01	8.03E-01
V14	4.39E-01	4.44E-01	-4.30E-01	1.31E+00
V15	6.02E-01	2.79E-01	5.44E-02	1.15E+00
V16	6.45E-01	4.04E-01	-1.47E-01	1.44E+00
V17	6.09E-01	3.79E-01	-1.35E-01	1.35E+00
V18	6.53E-01	1.91E-01	2.77E-01	1.03E+00
V19	3.43E-03	2.99E-01	-5.83E-01	5.90E-01
V20	3.77E-01	2.17E-01	-4.79E-02	8.01E-01
V21	9.92E-01	1.84E-01	6.32E-01	1.35E+00
V22	3.71E-01	5.01E-01	-6.11E-01	1.35E+00
V23	4.10E-01	2.80E-01	-1.39E-01	9.59E-01
V24	3.74E-01	1.34E-01	1.12E-01	6.37E-01
V25	3.13E-01	1.82E-01	-4.38E-02	6.69E-01
V26	1.91E-01	3.13E-01	-4.24E-01	8.05E-01
V27	1.16E-01	6.54E-01	-1.17E+00	1.40E+00
V28	1.66E-01	1.35E-01	-9.95E-02	4.32E-01
V29	3.23E-01	3.87E-01	-4.36E-01	1.08E+00
V30	5.86E-01	1.60E-01	2.73E-01	9.00E-01
V31	4.11E-01	2.42E-01	-6.34E-02	8.86E-01
V32	1.69E-01	1.39E-01	-1.04E-01	4.42E-01
V33	1.06E-01	1.30E-01	-1.50E-01	3.62E-01
V34	9.79E-01	1.64E-01	6.58E-01	1.30E+00
V35	6.62E-01	1.69E-01	3.30E-01	9.93E-01
V36	4.76E-02	2.10E-01	-3.65E-01	4.60E-01
V37	6.60E-01	1.52E-01	3.62E-01	9.58E-01
V38	4.78E-02	4.89E-01	-9.11E-01	1.01E+00
V39	-1.11E-01	2.02E-01	-5.07E-01	2.85E-01
V40	1.27E+00	1.80E-01	9.16E-01	1.62E+00

V41	5.39E-01	2.52E-01	4.39E-02	1.03E+00
V42	-7.82E-02	3.57E-01	-7.78E-01	6.22E-01

Non-Linear Least Squares Summary Statistics Dependent Variable NEWCAS HULL

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	49	140360	2864.491
Residual	3777	101145	26.77918
Uncorrected Total	3826	241505	
(Corrected Total)	3825	125416.2	

Model Coefficients for Dependent Variable NEWCAS HULL

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	3.89E+00	1.00E+00	1.93E+00	5.85E+00
V2	-5.20E+00	1.36E+00	-7.88E+00	-2.53E+00
V3	-4.75E-01	1.16E-01	-7.03E-01	-2.47E-01
V4	-6.11E-02	3.79E-02	-1.35E-01	1.32E-02
V5	2.15E-04	6.56E-05	8.68E-05	3.44E-04
V6	1.44E-05	1.68E-04	-3.15E-04	3.44E-04
V7	2.19E-09	1.46E-09	-6.77E-10	5.06E-09
V8	2.75E-02	9.29E-02	-1.55E-01	2.10E-01
V9	-3.69E-05	2.02E-05	-7.66E-05	2.79E-06
V10	-4.77E-07	2.05E-07	-8.78E-07	-7.61E-08
V11	6.77E-01	2.07E-01	2.71E-01	1.08E+00
V12	6.26E-01	1.82E-01	2.68E-01	9.83E-01
V13	8.23E-01	1.34E-01	5.60E-01	1.09E+00
V14	7.64E-01	1.09E-01	5.50E-01	9.78E-01
V15	5.31E-01	1.90E-01	1.58E-01	9.04E-01
V16	7.18E-01	2.18E-01	2.90E-01	1.15E+00
V17	4.81E-01	1.17E-01	2.51E-01	7.10E-01
V18	2.94E-01	8.88E-02	1.20E-01	4.68E-01
V19	2.55E-01	6.38E-02	1.30E-01	3.80E-01
V20	5.20E-01	1.28E-01	2.69E-01	7.71E-01
V21	4.10E-01	2.94E-01	-1.67E-01	9.87E-01
V22	4.68E-01	1.67E-01	1.41E-01	7.94E-01
V23	3.28E-01	3.61E-01	-3.80E-01	1.04E+00
V24	6.52E-01	1.61E-01	3.37E-01	9.67E-01
V25	-4.97E-01	2.71E-01	-1.03E+00	3.35E-02
V26	-2.18E+00	1.28E+00	-4.69E+00	3.38E-01
V27	3.05E-01	1.80E-01	-4.83E-02	6.58E-01
V28	-7.78E-01	5.42E-01	-1.84E+00	2.85E-01
V29	-9.51E-01	6.72E-01	-2.27E+00	3.66E-01
V30	-6.92E-01	3.54E 01	-1.39E+00	2.79E-03
V31	-1.29E+00	7.41E-01	-2.74E+00	1.64E-01
V32	-6.27E-01	3.81E-01	-1.37E+00	1.21E-01
V33	-1.61E+00	1.33E+00	-4.22E+00	9.99E-01
V34	-9.44E-02	1.10E-01	-3.10E-01	1.21E-01
V35	-1.32E+00	1.01E+00	-3.31E+00	6.69E-01
V36	-5.43E-01	4.53E-01	-1.43E+00	3.47E-01

V37	-7.19E-01	6.01E-01	-1.90E+00	4.59E-01
V38	-5.75E-01	3.98E-01	-1.35E+00	2.04E-01
V39	-8.81E-01	8.92E-01	-2.63E+00	8.67E-01
V40	-1.89E-01	1.66E-01	-5.14E-01	1.37E-01
V41	-9.97E-01	7.02E-01	-2.37E+00	3.80E-01
V42	-5.70E-02	8.91E-02	-2.32E-01	1.18E-01
V43	-1.36E-01	1.59E-01	-4.47E-01	1.74E-01
V44	2.70E-01	2.33E-01	-1.87E-01	7.27E-01
V45	-6.31E-01	6.45E-01	-1.90E+00	6.35E-01
V46	-2.58E-01	1.83E-01	-6.17E-01	1.01E-01
V47	-2.45E-01	2.75E-01	-7.84E-01	2.94E-01
V48	-6.14E-01	5.63E-01	-1.72E+00	4.90E-01
V49	-2.72E-01	3.92E-01	-1.04E+00	4.95E-01

Non-Linear Least Squares Summary Statistics Dependent Variable NEWCAS COMM

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	42	20444.37944	486.770939
Residual	3784	20473.62056	5.410576
Uncorrected Total	3826	40918	
(Corrected Total)	3825	26129.58285	

Model Coefficients for Dependent Variable NEWCAS COMM

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	3.61E+00	1.09E+00	1.48E+00	5.74E+00
V2	-3.80E+00	1.61E+00	-6.96E+00	-6.52E-01
V3	-3.56E-01	1.27E-01	-6.05E-01	-1.07E-01
V4	-1.93E-01	8.10E-02	-3.52E-01	-3.40E-02
V5	7.57E-05	5.36E-05	-2.94E-05	1.81E-04
V6	-6.94E-05	1.37E-04	-3.38E-04	1.99E-04
V7	1.01E-10	1.27E-09	-2.40E-09	2.60E-09
V8	-6.71E-02	9.02E-02	-2.44E-01	1.10E-01
V9	-8.69E-05	4.48E-05	-1.75E-04	8.02E-07
V10	-3.18E-07	1.73E-07	-6.57E-07	2.12E-08
V11	1.55E+00	3.71E-01	8.20E-01	2.28E+00
V12	1.18E+00	3.90E-01	4.18E-01	1.95E+00
V13	1.07E+00	3.08E-01	4.66E-01	1.67E+00
V14	1.20E+00	4.16E-01	3.88E-01	2.02E+00
V15	1.0[illegible]E+00	3.19E-01	4.02E-01	1.65E+00
V16	1.32E+00	4.45E-01	4.45E-01	2.19E+00
V17	1.33E+00	4.28E-01	4.93E-01	2.17E+00
V18	1.04E+00	3.25E-01	4.06E-01	1.68E+00
V19	1.13E+00	4.04E-01	3.36E-01	1.92E+00
V20	1.17E+00	3.18E-01	5.49E-01	1.80E+00
V21	1.07E+00	3.76E-01	3.29E-01	1.80E+00
V22	1.46E+00	2.35E-01	9.97E-01	1.92E+00
V23	1.56E+00	3.44E-01	8.89E-01	2.24E+00
V24	1.08E+00	4.68E-01	1.61E-01	2.00E+00
V25	5.73E-01	3.01E-01	-1.73E-02	1.16E+00
V26	7.53E-01	2.76E-01	2.12E-01	1.29E+00
V27	9.09E-01	2.58E-01	4.04E-01	1.41E+00

V28	7.02E-01	2.34E-01	2.43E-01	1.16E+00
V29	1.43E+00	6.26E-01	2.04E-01	2.66E+00
V30	9.87E-01	4.88E-01	2.98E-02	1.94E+00
V31	7.64E-01	3.26E-01	1.25E-01	1.40E+00
V32	7.68E-01	2.14E-01	3.49E-01	1.19E+00
V33	1.04E+00	5.47E-01	-3.29E-02	2.11E+00
V34	6.61E-01	1.79E-01	3.10E-01	1.01E+00
V35	4.00E-01	1.48E-01	1.10E-01	6.90E-01
V36	1.06E+00	4.75E-01	1.26E-01	1.99E+00
V37	1.15E+00	6.43E-02	1.02E+00	1.27E+00
V38	1.17E+00	5.24E-02	1.06E+00	1.27E+00
V39	9.03E-01	3.60E-01	1.96E-01	1.61E+00
V40	3.23E-01	2.37E-01	-1.42E-01	7.89E-01
V41	3.97E-01	2.17E-01	-2.78E-02	8.23E-01
V42	-9.25E-01	5.12E-01	-1.93E+00	8.03E-02

Non-Linear Least Squares Summary Statistics   Dependent Variable NEWCAS WEAP

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	45	28499.25468	633.316771
Residual	3781	23633.74532	6.25066
Uncorrected Total	3826	52133	
(Corrected Total)	3825	34784.95792	

Model Coefficients for Dependent Variable NEWCAS WEAP

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	1.52E+00	8.91E-02	1.34E+00	1.69E+00
V2	-4.38E+00	1.01E+00	-6.35E+00	-2.40E+00
V3	-2.86E-01	4.05E-02	-3.65E-01	-2.06E-01
V4	-1.10E-01	1.45E-02	-1.39E-01	-8.19E-02
V5	1.79E-04	4.11E-05	9.83E-05	2.59E-04
V6	1.18E-04	1.18E-04	-1.12E-04	3.49E-04
V7	9.63E-10	1.43E-09	-1.83E-09	3.76E-09
V8	1.77E-01	6.61E-02	4.69E-02	3.06E-01
V9	-1.13E-04	1.41E-05	-1.41E-04	-8.57E-05
V10	-1.18E-07	6.79E-08	-2.51E-07	1.49E-08
V11	2.69E+00	2.10E-01	2.28E+00	3.10E+00
V12	2.42E+00	2.10E-01	2.00E+00	2.83E+00
V13	2.44E+00	2.15E-01	2.01E+00	2.86E+00
V14	2.67E+00	2.08E-01	2.27E+00	3.08E+00
V15	2.07E+00	2.07E-01	1.66E+00	2.48E+00
V16	1.92E+00	2.07E-01	1.51E+00	2.33E+00
V17	2.07E+00	2.24E-01	1.63E+00	2.51E+00
V18	2.31E+00	2.31E-01	1.86E+00	2.76E+00
V19	2.53E+00	2.58E-01	2.03E+00	3.04E+00
V20	1.87E+00	2.22E-01	1.44E+00	2.31E+00
V21	1.90E+00	2.26E-01	1.46E+00	2.34E+00
V22	2.04E+00	2.54E-01	1.54E+00	2.54E+00
V23	1.64E+00	2.46E-01	1.16E+00	2.12E+00
V24	1.66E+00	2.45E-01	1.18E+00	2.14E+00
V25	2.30E+00	3.11E-01	1.69E+00	2.91E+00

V26	1.91E+00	2.56E-01	1.40E+00	2.41E+00
V27	1.68E+00	2.69E-01	1.15E+00	2.21E+00
V28	2.27E+00	2.94E-01	1.70E+00	2.85E+00
V29	1.29E+00	2.49E-01	8.05E-01	1.78E+00
V30	1.50E+00	2.78E-01	9.58E-01	2.05E+00
V31	1.39E+00	2.79E-01	8.47E-01	1.94E+00
V32	1.70E+00	2.99E-01	1.11E+00	2.29E+00
V33	1.28E+00	2.90E-01	7.14E-01	1.85E+00
V34	1.67E+00	3.77E-01	9.27E-01	2.41E+00
V35	1.93E+00	3.53E-01	1.24E+00	2.62E+00
V36	1.42E+00	4.46E-01	5.44E-01	2.29E+00
V37	1.04E+00	2.70E-01	5.10E-01	1.57E+00
V38	1.46E+00	3.26E-01	8.26E-01	2.10E+00
V39	1.30E+00	3.27E-01	6.55E-01	1.94E+00
V40	1.08E+00	3.28E-01	4.42E-01	1.73E+00
V41	7.41E-01	2.11E-01	3.27E-01	1.15E+00
V42	1.54E+00	3.44E-01	8.68E-01	2.22E+00
V43	5.01E-01	1.65E-01	1.77E-01	8.25E-01
V44	1.11E+00	2.44E-01	6.27E-01	1.58E+00
V45	1.03E+00	3.40E-01	3.64E-01	1.70E+00

APPENDIX D. FITTED SIM

Appendix D contains the SAS output for the model fit of the SIM submodels from the full model run.

Non-Linear Least Squares Summary Statistics   Dependent Variable MTTC HULL

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	29	1231519	42466.16
Residual	3475	1312882	377.8078
Uncorrected Total	3504	2544401	
(Corrected Total)	3503	1449663	

Model Coefficients for Dependent Variable MTTC HULL

Parameter	*Estimate*	*Asymptotic Std. Error*	*Asymptotic 95% Confidence Interval Lower*	*Upper*
V116	3.30E+00	4.08E-01	2.50E+00	4.10E+00
V117	-5.59E-01	1.07E+00	-2.65E+00	1.53E+00
V119	5.79E-01	7.10E-02	4.40E-01	7.19E-01
V120	9.03E-01	1.82E-01	5.47E-01	1.26E+00
V121	-3.01E-01	9.15E-02	-4.80E-01	-1.21E-01
V122	-3.03E-01	1.03E-01	-5.05E-01	-1.01E-01
V123	3.46E-03	3.41E-02	-6.35E-02	7.04E-02
V124	2.63E-01	1.73E-01	-7.57E-02	6.01E-01
V125	4.85E-01	2.91E-01	-8.49E-02	1.06E+00
V127	4.36E-01	1.18E-01	2.04E-01	6.68E-01
V128	9.86E-01	1.59E-01	6.73E-01	1.30E+00
V129	5.50E-01	1.37E-01	2.81E-01	8.19E-01
V130	8.44E-01	1.98E-01	4.57E-01	1.23E+00
V131	8.06E-01	1.55E-01	5.02E-01	1.11E+00
V133	5.31E-01	2.00E-01	1.39E-01	9.22E-01
V134	5.21E-01	1.97E-01	1.34E-01	9.07E-01
V135	4.91E-01	1.54E-01	1.90E-01	7.92E-01
V136	4.74E-01	1.39E-01	2.02E-01	7.46E-01
V137	1.19E-01	3.38E-01	-5.44E-01	7.81E-01
V138	6.00E-01	1.40E-01	3.25E-01	8.75E-01
V141	3.16E-01	1.43E-01	3.61E-02	5.95E-01
V142	2.49E-01	1.37E-01	-2.08E-02	5.18E-01
V143	2.63E-01	1.15E-01	3.64E-02	4.89E-01
V144	-7.63E-02	1.52E-01	-3.74E-01	2.21E-01
V145	3.41E-01	1.72E-01	4.72E-03	6.78E-01
V146	4.43E-01	2.48E-01	-4.35E-02	9.28E-01
V147	-1.48E-01	3.36E-01	-8.06E-01	5.11E-01
V148	7.21E-01	1.86E-01	3.56E-01	1.09E+00
V201	-1.95E-04	3.51E-05	-2.64E-04	-1.26E-04

Non-Linear Least Squares Summary Statistics Dependent Variable MTTC COMM

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	21	548673.9	26127.33
Residual	3483	978213.5	280.8537
Uncorrected Total	3504	1526887	
(Corrected Total)	3503	1057814	

Model Coefficients for Dependent Variable MTTC COMM

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V149	3.53E+00	5.20E-01	2.51E+00	4.55E+00
V150	-3.43E+00	1.78E+00	-6.91E+00	5.93E-02
V151	-4.34E-02	3.67E-02	-1.15E-01	2.86E-02
V152	1.55E-01	2.74E-01	-3.83E-01	6.92E-01
V153	2.38E-02	8.98E-02	-1.52E-01	2.00E-01
V154	-4.27E-01	2.07E-01	-8.33E-01	-2.22E-02
V155	6.24E-01	1.24E-01	3.81E-01	8.66E-01
V156	5.35E-01	3.51E-01	-1.53E-01	1.22E+00
V157	5.15E-01	1.49E-01	2.23E-01	8.06E-01
V158	5.07E-01	1.03E-01	3.04E-01	7.09E-01
V159	5.28E-01	2.97E-01	-5.39E-02	1.11E+00
V160	5.11E-01	1.19E-01	2.78E-01	7.45E-01
V161	6.70E-01	1.50E-01	3.76E-01	9.64E-01
V162	6.60E-01	1.65E-01	3.36E-01	9.83E-01
V163	5.48E-01	1.10E-01	3.34E-01	7.63E-01
V164	5.60E-01	1.95E-01	1.77E-01	9.43E-01
V165	6.70E-01	2.15E-01	2.48E-01	1.09E+00
V166	5.77E-01	1.86E-01	2.13E-01	9.41E-01
V167	9.06E-01	2.71E-01	3.75E-01	1.44E+00
V170	7.13E-01	2.60E-01	2.02E-01	1.22E+00
V202	-2.55E-04	5.21E-05	-3.58E-04	-1.53E-04

Non-Linear Least Squares Summary Statistics Dependent Variable MTTC WEAP

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	14	782968.2	55926.3
Residual	3490	2793817	800.5208
Uncorrected Total	3504	3576786	
(Corrected Total)	3503	2905411	

Model Coefficients for Dependent Variable MTTC WEAP

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V171	5.06E+00	3.93E-01	4.29E+00	5.84E+00
V172	2.83E+00	1.86E+00	-8.21E-01	6.48E+00
V173	6.06E-01	2.00E-01	2.14E-01	9.97E-01
V174	-6.51E-01	9.38E-02	-8.35E-01	-4.67E-01
V175	-8.80E-01	2.14E-01	-1.30E+00	-4.61E-01
V176	1.19E+00	5.77E-01	5.45E-02	2.32E+00
V177	8.00E-01	2.28E-01	3.53E-01	1.25E+00
V179	-8.39E-01	2.57E-01	-1.34E+00	-3.35E-01

V180	-1.18E+00	6.16E-01	-2.39E+00	2.73E-02
V181	-8.50E-02	3.14E-02	-1.47E-01	-2.34E-02
V182	-6.80E-01	2.94E-01	-1.26E+00	-1.04E-01
V183	1.32E+00	4.43E-01	4.47E-01	2.18E+00
V184	5.71E-03	1.28E-01	-2.46E-01	2.57E-01
V203	3.14E-05	6.36E-05	-9.32E-05	1.56E-04

Non-Linear Least Squares Summary Statistics   Dependent Variable NEWCAS HULL

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	34	113559.7	3339.992
Residual	3470	88227.26	25.42572
Uncorrected Total	3504	201787	
(Corrected Total)	3503	103552.5	

Model Coefficients for Dependent Variable NEWCAS HULL

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V83	1.15E+00	2.78E-01	6.02E-01	1.69E+00
V84	-8.04E+00	1.02E+00	-1.00E+01	-6.04E+00
V85	-2.42E-01	8.62E-02	-4.11E-01	-7.29E-02
V86	2.39E-01	1.18E-01	8.22E-03	4.70E-01
V87	4.89E-01	1.11E-01	2.72E-01	7.07E-01
V88	9.29E-01	1.17E-01	6.98E-01	1.16E+00
V89	1.16E-01	1.23E-01	-1.25E-01	3.57E-01
V90	-1.31E+00	4.92E-01	-2.27E+00	-3.46E-01
V91	-1.84E+00	4.58E-01	-2.73E+00	-9.39E-01
V92	-2.42E+00	1.85E+00	-6.06E+00	1.21E+00
V93	-7.65E-01	3.88E+00	-8.37E+00	6.84E+00
V94	4.41E-01	1.13E-01	2.20E-01	6.62E-01
V95	7.28E-01	6.67E-02	5.98E-01	8.59E-01
V96	6.29E-01	6.89E-02	4.94E-01	7.64E-01
V97	7.09E-01	5.24E-02	6.06E-01	8.11E-01
V98	3.11E-01	6.92E-02	1.75E-01	4.46E-01
V99	3.73E-01	1.14E-01	1.50E-01	5.96E-01
V100	7.39E-01	7.21E-02	5.98E-01	8.81E-01
V101	3.90E-01	8.32E-02	2.27E-01	5.53E-01
V102	8.37E-01	6.55E-02	7.09E-01	9.66E-01
V103	9.41E-01	1.20E-01	7.06E-01	1.18E+00
V104	7.56E-01	1.20E-01	5.22E-01	9.91E-01
V105	1.03E+00	1.10E-01	8.10E-01	1.24E+00
V106	8.09E-02	9.39E-02	-1.03E-01	2.65E-01
V107	-3.46E-01	8.19E-02	-5.07E-01	-1.86E-01
V108	8.23E-01	1.22E-01	5.83E-01	1.06E+00
V109	-4.35E-01	5.16E-02	-5.36E-01	-3.34E-01
V110	7.08E-02	8.25E-03	5.46E-02	8.70E-02
V111	2.71E-04	1.25E-05	2.46E-04	2.95E-04
V112	-4.75E-10	7.49E-10	-1.94E-09	9.93E-10
V113	-1.97E-02	5.13E-02	-1.20E-01	8.10E-02
V114	-8.57E-05	1.24E-05	-1.10E-04	-6.14E-05
V115	-1.99E-07	1.44E-07	-4.80E-07	8.28E-08

V204	2.43E-03	1.92E-04	2.06E-03	2.81E-03

Non-Linear Least Squares Summary Statistics Dependent Variable NEWCAS COMM

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	34	15939.06	468.7959
Residual	3470	17012.94	4.902864
Uncorrected Total	3504	32952	
(Corrected Total)	3503	21042.3	

Model Coefficients for Dependent Variable NEWCAS COMM

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	1.75E-01	4.25E+01	-8.32E+01	8.35E+01
V2	8.08E-01	2.52E+00	-4.14E+00	5.76E+00
V3	-2.28E-01	1.95E+00	-4.05E+00	3.59E+00
V4	-8.19E-02	1.11E+00	-2.25E+00	2.09E+00
V5	3.92E-05	4.49E-04	-8.41E-04	9.20E-04
V6	-4.36E-02	3.02E-01	-6.35E-01	5.48E-01
V7	-5.49E-05	1.86E-04	-4.19E-04	3.09E-04
V8	-2.11E-07	1.80E-06	-3.75E-06	3.33E-06
V9	-2.23E-01	3.30E-02	-2.88E-01	-1.59E-01
V10	4.34E-01	3.72E-02	3.61E-01	5.07E-01
V11	-3.90E-01	3.97E-01	-1.17E+00	3.89E-01
V12	-8.09E-01	3.41E+00	-7.50E+00	5.88E+00
V13	-7.63E-01	4.49E+00	-9.57E+00	8.04E+00
V14	-9.60E-01	3.71E+00	-8.24E+00	6.32E+00
V15	1.18E+00	4.15E+00	-6.96E+00	9.32E+00
V16	5.46E-01	2.67E+00	-4.68E+00	5.77E+00
V17	5.88E-01	2.34E+00	-3.99E+00	5.17E+00
V18	1.04E+00	5.34E+00	-9.43E+00	1.15E+01
V19	4.61E-01	1.01E+00	-1.53E+00	2.45E+00
V20	8.21E-01	3.34E+00	-5.73E+00	7.38E+00
V21	4.10E-01	1.02E+00	-1.60E+00	2.42E+00
V22	1.08E+00	2.27E+00	-3.38E+00	5.54E+00
V23	5.22E-01	2.22E+00	-3.83E+00	4.87E+00
V24	6.40E-01	2.70E+00	-4.66E+00	5.94E+00
V25	9.91E-01	1.38E+00	-1.72E+00	3.70E+00
V26	5.24E-01	2.33E+00	-4.04E+00	5.09E+00
V27	1.01E+00	3.25E+00	-5.36E+00	7.37E+00
V28	6.82E-01	3.24E+00	-5.67E+00	7.03E+00
V29	5.46E-01	2.21E+00	-3.79E+00	4.88E+00
V30	7.46E-01	3.81E+00	-6.72E+00	8.21E+00
V31	8.54E-01	4.62E+00	-8.20E+00	9.90E+00
V32	-5.38E-01	2.00E+00	-4.46E+00	3.39E+00
V33	7.79E-01	2.38E+00	-3.88E+00	5.44E+00
V205	4.01E-03	9.68E-03	-1.50E-02	2.30E-02

Non-Linear Least Squares Summary Statistics Dependent Variable NEWCAS WEAP

Source	*DF*	*Sum of Squares*	*Mean Square*
Regression	29	23519.66	811.0229

Residual	3475	22056.34	6.347147
Uncorrected Total	3504	45576	
(Corrected Total)	3503	30342.66	

Model Coefficients for Dependent Variable NEWCAS WEAP

		Asymptotic	*Asymptotic 95% Confidence Interval*	
Parameter	*Estimate*	*Std. Error*	*Lower*	*Upper*
V1	-1.22E-01	2.85E-01	-6.81E-01	4.38E-01
V2	-2.13E-01	6.01E-02	-3.31E-01	-9.48E-02
V3	1.53E-04	6.38E-05	2.83E-05	2.78E-04
V4	9.18E-05	1.35E-05	6.54E-05	1.18E-04
V5	1.17E-09	2.95E-09	-4.61E-09	6.95E-09
V6	1.81E-01	8.24E-02	1.99E-02	3.43E-01
V7	-8.25E-05	6.87E-06	-9.59E-05	-6.90E-05
V8	-1.71E-07	2.44E-08	-2.19E-07	-1.23E-07
V9	7.39E-01	1.72E-01	4.02E-01	1.08E+00
V10	1.39E+00	1.04E-01	1.18E+00	1.59E+00
V11	1.02E+00	2.64E-01	4.98E-01	1.54E+00
V12	8.88E-01	2.32E-01	4.32E-01	1.34E+00
V13	1.46E+00	2.86E-01	8.96E-01	2.02E+00
V14	1.33E+00	2.66E-01	8.04E-01	1.85E+00
V15	1.24E+00	2.75E-01	7.03E-01	1.78E+00
V16	1.25E+00	2.40E-01	7.78E-01	1.72E+00
V17	4.83E-01	6.74E-02	3.51E-01	6.16E-01
V18	6.25E-01	1.62E-01	3.07E-01	9.42E-01
V19	1.61E+00	2.87E-01	1.04E+00	2.17E+00
V20	1.38E+00	2.91E-01	8.07E-01	1.95E+00
V21	9.90E-01	2.56E-01	4.89E-01	1.49E+00
V22	9.42E-01	2.62E-01	4.28E-01	1.46E+00
V23	1.62E+00	2.61E-01	1.11E+00	2.14E+00
V24	1.31E+00	2.89E-01	7.44E-01	1.88E+00
V25	9.00E-01	2.43E-01	4.23E-01	1.38E+00
V26	-4.07E-01	1.64E-01	-7.30E-01	-8.47E-02
V27	6.88E-01	1.71E-01	3.52E-01	1.02E+00
V28	7.15E-01	1.39E-01	4.42E-01	9.88E-01
V206	1.86E-03	3.00E-04	1.27E-03	2.45E-03

APPENDIX E. CODE USED FOR CROSS VALIDATION OF THE SRM

Appendix E contains the code used for Cross-Validation of the SRM. It only contains code that is different from Appendix A. Where the comment [*Same code as in Appendix A*] appears, the code for the cross validation is identical to the code in Appendix A.

```
//SRM2A JOB CLASS=C,USER=S6402
//*MAIN LINES=(99)
// EXEC SAS
//WORK DD UNIT=SYSDA,SPACE=(CYL,(100,5))
//PDAT DD UNIT=SYSDA,DISP=SHR,DSN=MSS.S6402.FY92.POTF
//REG2 DD DISP=SHR,DSN=MSS.S6402.MATHTECH
//NEWDAT DD DISP=(NEW,CATLG),UNIT=SYSDA,
// SPACE=(TRK,(260,1),RLSE),
// DSN=MSS.S6402.FY92.FMDB.LAG
//RESLTZ DD DISP=(NEW,CATLG),UNIT=SYSDA,
// SPACE=(TRK,(10,10),RLSE),
// DSN=MSS.S6402.FY92.RESULTS
//SYSIN DD *

OPTIONS LS=132;
 DATA R2;
 SET REG2.MASTER92;
```

[*Same code as in Appendix A*]

```
 DATA R2; SET R2;
 NEWWEAP1=NEWWEAP;
 NEWCOMM1=NEWCOMM;
 NEWHULL1=NEWHULL;
 MTTCH1=MTTCH;
 MTTCC1=MTTCC;
 MTTCW1=MTTCW;
 IF YEAR=91 OR YEAR=92 THEN DO
 NEWWEAP=.; NEWCOMM=.; NEWHULL=.;
 MTTCH=. ; MTTCC=. ; MTTCW=. ;
 END;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
 PROC NLIN METHOD = DUD MAXITER = 50    /* MTTC HULL */
 CONVERGE = .001 DATA=R2 EFORMAT;
```

[*Same code as in Appendix A*]

```
/* CREATE AND SORT THE SET MTTCW */
```

```
DATA MTTCW;
SET RESLTZ.MTTCW;
KEEP TYPE HULL YEAR PMTTCW MTTCW MTTCW1 POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA PD ; SET PD ;
PROC SUMMARY NWAY ; VAR NOPDAY ; CLASS YEAR ;
OUTPUT OUT=OPDAYS SUM= TOTALOP ;

/* CREATE A SAS DATA SET NAMED 'WHOLE' CONSISTING OF THE VARIABLES
  LISTED IN THE MERGE AND SORTED BY TYPE,HULL,YEAR */
DATA WHOLE;
MERGE NHULL NCOMM NWEAP MTTCH MTTCC MTTCW PD;
BY TYPE HULL YEAR;
IF PMTTCW=. THEN DELETE;
IF PMTTCH=. THEN DELETE;
IF PMTTCC=. THEN DELETE;
PROC SORT ; BY YEAR ;

DATA WHOLE ; MERGE OPDAYS WHOLE ; BY YEAR ;

DATA COMBINE;
SET WHOLE;
IF YEAR=91 OR YEAR=92 THEN DO
NEWWEAP=NEWWEAP1;
NEWCOMM=NEWCOMM1;
NEWHULL=NEWHULL1;
MTTCH=MTTCH1;
MTTCC=MTTCC1;
MTTCW=MTTCW1;
END;

/* CALCULATE THE FOLLOWING FOUR VARIABLES */
NEWCAS = NEWCOMM + NEWHULL + NEWWEAP;
PNEWCAS = PNCOMM + PNHULL + PNWEAP;
MTTC = (NEWHULL/NEWCAS)*MTTCH + (NEWWEAP/NEWCAS)*MTTCW +
   (NEWCOMM/NEWCAS)*MTTCC;
PMTTC = (PNHULL/PNEWCAS)*PMTTCH + (PNWEAP/PNEWCAS)*PMTTCW +
   (PNCOMM/PNEWCAS)*PMTTCC;
PPOTF = EXP(-.0024*
(PNHULL*PMTTCH+PNCOMM*PMTTCC+PNWEAP*PMTTCW));
PPOTF = PPOTF * 100;

WPPOTF = PPOTF*NOPDAY/TOTALOP ;
WPOTF = POTF * NOPDAY / TOTALOP ;

POTFDIF = PPOTF - POTF;
WPOTFDIF = WPPOTF - WPOTF ;
MTTCDIF = PMTTC - MTTC;
NCASDIF = PNEWCAS - NEWCAS;
```

```
MTTCHDIF = PMTTCH - MTTCH;
MTTCCDIF = PMTTCC - MTTCC;
MTTCWDIF = PMTTCW - MTTCW;
NHULLDIF = PNHULL - NEWHULL;
NCOMMDIF = PNCOMM - NEWCOMM;
NWEAPDIF = PNWEAP - NEWWEAP;

POTFSQR = POTFDIF**2;
WPOTFSQR = WPOTFDIF**2;
MTTCSQR = MTTCDIF**2;
NCASSQR = NCASDIF**2;

MTTCHSQR = MTTCHDIF**2;
MTTCCSQR = MTTCCDIF**2;
MTTCWSQR = MTTCWDIF**2;
NHULLSQR = NHULLDIF**2;
NCOMMSQR = NCOMMDIF**2;
NWEAPSQR = NWEAPDIF**2;

IF POTF NE 0 THEN MREPOTF = ABS(POTFDIF) / ABS(POTF) ;
IF WPOTF NE 0 THEN MREWPOTF = ABS(WPOTFDIF) / ABS(WPOTF) ;
IF MTTC NE 0 THEN MREMTTC = ABS(MTTCDIF) / ABS(MTTC) ;
IF NEWCAS NE 0 THEN MRENCAS = ABS(NCASDIF) / ABS(NEWCAS) ;
IF MTTCH NE 0 THEN MREMTTCH = ABS(MTTCHDIF) / ABS(MTTCH) ;
IF MTTCC NE 0 THEN MREMTTCC = ABS(MTTCCDIF) / ABS(MTTCC) ;
IF MTTCW NE 0 THEN MREMTTCW = ABS(MTTCWDIF) / ABS(MTTCW) ;
IF NEWHULL NE 0 THEN MRENHULL = ABS(NHULLDIF) / ABS(NEWHULL) ;
IF NEWCOMM NE 0 THEN MRENCOMM = ABS(NCOMMDIF) / ABS(NEWCOMM) ;
IF NEWWEAP NE 0 THEN MRENWEAP = ABS(NWEAPDIF) / ABS(NEWWEAP) ;

PROC SORT; BY YEAR;

DATA APPLY; SET COMBINE; IF YEAR = 91 OR YEAR = 92;

PROC SUMMARY PRINT MEAN ; WEIGHT NOPDAY ;
VAR POTF PPOTF ;
CLASS YEAR ;
OUTPUT OUT=PREDPOTF MEAN=MEANPOTF;
TITLE 'PROC SUMMARY OF POTF VALUES USING PRINT OPTION' ;

PROC PRINT DATA=PREDPOTF ;
TITLE 'PROC SUMMARY OF POTF VALUES USING PROC PRINT' ;

DATA APPLY ; SET APPLY ;
PROC MEANS SUM MEAN ;
VAR PCTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR
  MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH MTTCHSQR
MREMTTCH
  MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW MTTCWSQR MREMTTCW
```

```
  NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM PNCOMM NCOMMSQR
MRENCOMM
  NEWWEAP PNWEAP NWEAPSQR MRENWEAP .
 BY YEAR.
 TITLE 'PROC MEANS OF POTF VALUES BY YEAR

 PROC MEANS SUM MEAN .
 VAR POTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH
MTTCHSQR MREMTTCH MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW
MTTCWSQR MREMTTCW NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM
PNCOMM NCOMMSQR MRENCOMM NEWWEAP PNWEAP NWEAPSQR MRENWEAP
 TITLE PROC MEANS OF POTF VALUES OVERALL
 PROC SORT BY YEAR
```

APPENDIX F. CODE USED FOR CROSS VALIDATION OF THE SIM

Appendix F contains the code used for Cross-Validation of the SIM. It only contains code that is different from Appendix B. Where the comment [*Same code as in Appendix B*] appears, the code for the cross validation is identical to the code in Appendix B.

```
//SIM2A  JOB USER=S6402 CLASS=C
//  EXEC SAS
//WORK DD UNIT=SYSDA SPACE=(CYL,(10,10))
//PDAT DD UNIT=SYSDA DISP=SHR DSN=MSS.S6402.FY92.POTF
//REG2 DD DISP=SHR DSN=MSS.S6402.MATHTECH
//RESULTZ DD DSN=MSS.S6402.FY91.MODEL.PREDACTS,
// DISP=(OLD,KEEP),UNIT=SYSDA,
// SPACE=(TRK,(10,10),RLSE)
//SYSIN DD *

OPTIONS LS=132;
DATA STOCKF;
```

[*Same code as in Appendix B*]

```
DATA R2; SET R2;
NEWWEAP1=NEWWEAP;
NEWCOMM1=NEWCOMM;
NEWHULL1=NEWHULL;
MTTCH1=MTTCH;
MTTCC1=MTTCC;
MTTCW1=MTTCW;
IF YEAR=91 OR YEAR=92 THEN DO;
NEWWEAP=.; NEWCOMM=.; NEWHULL=.;
MTTCH=.;   MTTCC=.;    MTTCW=.;
END;

/* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
  FACTOR .001 */
PROC NLIN METHOD = DUD MAXITER = 50 G4   /* MTTC HULL */
CONVERGE = .001 DATA=R2 EFORMAT;
```

[*Same code as in Appendix B*]

```
/* CREATE AND SORT THE SET MTTCW */
DATA MTTCW;
SET RESULTZ.MTTCW;
KEEP TYPE HULL YEAR PMTTCW MTTCW MTTCW1 POTF ;
PROC SORT; BY TYPE HULL YEAR;

DATA PD; SET PD;
```

```
PROC SUMMARY NWAY . VAR NOPDAY ; CL.,SS YEAR ;
OUTPUT OUT=OPDAYS SUM= TOTALOP ;

/* CREATE A SAS DATA SET NAMED 'WHOLE' CONSISTING OF THE VARIABLES
  LISTED IN THE MERGE AND SORTED BY TYPE.HULL.YEAR */
DATA WHOLE.
MERGE NHULL NCOMM NWEAP MTTCH MTTCC MTTCW PD:
BY TYPE HULL YEAR.
IF PMTTCW=  THEN DELETE.
IF PMTTCH=  THEN DELETE.
IF PMTTCC=  THEN DELETE.
PROC SORT . BY YEAR .

DATA WHOLE . MERGE OPDAYS WHOLE . BY  : t ' . .

DATA COMBINE.
SET WHOLE.
IF YEAR=91 OR YEAR=92 THEN DO
NEWWEAP=NEWWEAP1.
NEWCOMM=NEWCOMM1.
NEWHULL=NEWHULL1.
MTTCH=MTTCH1.
MTTCC=MTTCC1.
MTTCW=MTTCW1.
END;

/* CALCULATE THE FOLLOWING FOUR VARIABLES */
NEWCAS = NEWCOMM + NEWHULL + NEWWEAP.
PNEWCAS = PNCOMM + PNHULL + PNWEAP:
MTTC = (NEWHULL/NEWCAS)*MTTCH + (NEWWEAP/NEWCAS)*MTTCW +
   (NEWCOMM/NEWCAS)*MTTCC;
PMTTC = (PNHULL/PNEWCAS)*PMTTCH + (PNWEAP/PNEWCAS)*PMTTCW +
   (PNCOMM/PNEWCAS)*PMTTCC;
PPOTF = EXP(-.0024*
(PNHULL*PMTTCH+PNCOMM*PMTTCC+PNWEAP*PMTTCW));
PPOTF = PPOTF * 100;

WPPOTF = PPOTF*NOPDAY/TOTALOP ;
WPOTF = POTF * NOPDAY / TOTALOP ;

POTFDIF = PPOTF - POTF;
WPOTFDIF = WPPOTF - WPOTF ;
MTTCDIF = PMTTC - MTTC;
NCASDIF = PNEWCAS - NEWCAS;

MTTCHDIF = PMTTCH - MTTCH;
MTTCCDIF = PMTTCC - MTTCC;
MTTCWDIF = PMTTCW - MTTCW;
NHULLDIF = PNHULL - NEWHULL;
NCOMMDIF = PNCOMM - NEWCOMM;
NWEAPDIF = PNWEAP - NEWWEAP;
```

```
POTFSQR = POTFDIF**2;
WPOTFSQR = WPOTFDIF**2;

MTTCSQR = MTTCDIF**2;
NCASSQR = NCASDIF**2;

MTTCHSQR = MTTCHDIF**2;
MTTCCSQR = MTTCCDIF**2;
MTTCWSQR = MTTCWDIF**2;
NHULLSQR = NHULLDIF**2;
NCOMMSQR = NCOMMDIF**2;
NWEAPSQR = NWEAPDIF**2;

IF POTF NE 0 THEN MREPOTF = ABS(POTFDIF) / ABS(POTF) ;
IF WPOTF NE 0 THEN MREWPOTF = ABS(WPOTFDIF) / ABS(WPOTF) ;
IF MTTC NE 0 THEN MREMTTC = ABS(MTTCDIF) / ABS(MTTC) ;
IF NEWCAS NE 0 THEN MRENCAS = ABS(NCASDIF) / ABS(NEWCAS) ;
IF MTTCH NE 0 THEN MREMTTCH = ABS(MTTCHDIF) / ABS(MTTCH) ;
IF MTTCC NE 0 THEN MREMTTCC = ABS(MTTCCDIF) / ABS(MTTCC) ;
IF MTTCW NE 0 THEN MREMTTCW = ABS(MTTCWDIF) / ABS(MTTCW) ;
IF NEWHULL NE 0 THEN MRENHULL = ABS(NHULLDIF) / ABS(NEWHULL) ;
IF NEWCOMM NE 0 THEN MRENCOMM = ABS(NCOMMDIF) / ABS(NEWCOMM) ;
IF NEWWEAP NE 0 THEN MRENWEAP = ABS(NWEAPDIF) / ABS(NEWWEAP) ;

PROC SORT; BY YEAR;

DATA APPLY; SET COMBINE; IF YEAR = 91 OR YEAR = 92;

PROC SUMMARY PRINT MEAN ; WEIGHT NOPDAY ;
VAR POTF PPOTF ;
CLASS YEAR ;
OUTPUT OUT=PREDPOTF MEAN=AVGWPOTF AVGWPPTF ;
TITLE 'PROC SUMMARY OF POTF VALUES USING PRINT OPTION' ;

PROC PRINT DATA=PREDPOTF ;
TITLE 'PROC SUMMARY OF POTF VALUES USING PROC PRINT' ;

DATA APPLY ; SET APPLY ;
PROC MEANS SUM MEAN ;
VAR POTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH
MTTCHSQR MREMTTCH MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW
MTTCWSQR MREMTTCW NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM
PNCOMM NCOMMSQR MRENCOMM NEWWEAP PNWEAP NWEAPSQR MRENWEAP ;
BY YEAR;
TITLE 'PROC MEANS OF POTF VALUES BY YEAR' ;

PROC MEANS SUM MEAN ;
VAR POTF PPOTF POTFSQR WPOTF WPPOTF WPOTFSQR MREWPOTF MTTC PMTTC
MTTCSQR MREMTTC NEWCAS PNEWCAS NCASSQR MRENCAS MTTCH PMTTCH
```

```
MTTCHSQR MREMTTCH MTTCC PMTTCC MTTCCSQR MREMTTCC MTTCW PMTTCW
MTTCWSQR MREMTTCW NEWHULL PNHULL NHULLSQR MRENHULL NEWCOMM
PNCOMM NCOMMSQR MRENCOMM NEWWEAP PNWEAP NWEAPSQR MRENWEAP ;
 TITLE 'PROC MEANS OF POTF VALUES OVERALL' ;
 PROC SORT; BY YEAR;

 DATA APPLY; SET COMBINE; IF YEAR = 91 OR YEAR = 92;
```

APPENDIX G. ANNUAL DESCRIPTIVE STATISTICS FOR DATA SET

Appendix G contains the annual descriptive statistics from the data set from 1982-1992. It includes all the dependent variables and the non-ship-class predictor variables.

Fiscal Year 1982

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	334	51.4882	29.28611	0	100
$POTF_{FLEET}$		44.26166	0	44.26166	44.26166
MTTC	334	26.00898	19.26619	1	148
NEWCAS	334	13.02096	10.44661	1	63
ORDREW	334	95115.78	325253.8	0	3459083
HRSUWM1	334	2264.89	1374.84	0	5513
LGLDPE	334	169.4042	148.614	0	770
TSLDPE	334	335.8743	384.344	0	3286
MOD	334	0	0	0	0
TOP3PR	334	0.056404	0.021908	0	0.144578
AGPARTPS	334	2.108179	0	2.108179	2.108179
AGLABPS	334	10.60686	0	10.60686	10.60686
DEPOTM1	334	6362602	10867675	0	75627509
RFI	334	1106	0	1106	1106
ACWT	334	563	0	563	563
MTTC (HULL)	334	24.27696	23.598	0	148
MTTC (COMM)	334	18.23374	21.42419	0	151
MTTC (WEAP)	334	18.97493	42.35832	0	521
NEWCAS (HULL)	334	7.736527	7.380441	0	41
NEWCAS (COMM)	334	3.05988	3.831591	0	39
NEWCAS (WEAP)	334	2.583832	3.854389	0	35

Fiscal Year 1983

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	331	60.47323	25.21913	0	100
POTF(FLEET)	1	54.23442	0	54.23442	54.23442
MTTC	331	22.48036	17.76689	1	192
NEWCAS	331	11.54683	8.928338	1	55
ORDREW	331	93855.74	301297.7	0	2903624
HRSUWM1	331	2173.62	1310.72	0	5522
LGLDPE	331	166.7825	152.6551	0	889
TSLDPE	331	344.8792	414.4685	0	3651
MOD	331	0.009063	0.094913	0	1
TOP3PR	331	0.057618	0.01683	0	0.15
AGPARTPS	331	2.429752	0	2.429752	2.429752
AGLABPS	331	11.98898	0	11.98898	11.98898
DEPOTM1	331	7329710	16152195	-62619.3	1.42E+08
RFI	331	1642	0	1642	1642
ACWT	331	514	0	514	514
MTTC (HULL)	331	21.32301	23.26564	0	192

MTTC (COMM)	331	16.84776	21.11987	0	114
MTTC (WEAP)	331	13.887	20.07622	0	173
NEWCAS (HULL)	331	6.770393	6.939686	0	40
NEWCAS (COMM)	331	2.655589	2.938118	0	16
NEWCAS (WEAP)	331	2.492447	3.36413	0	17

Fiscal Year 1984

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	322	64.09062	24.68082	0	99.45
POTF(FLEET)	1	56.49889	0	56.49889	56.49889
MTTC	322	21.72981	20.94151	2	186
NEWCAS	322	10.18634	8.043654	1	42
ORDREW	322	82125.73	311584.3	0	4100565
HRSUWM1	322	2294.52	1359.95	0	5111
LGLDPE	322	146.2764	132.1288	0	889
TSLDPE	322	363.5528	363.9529	0	2430
MOD	322	0.034162	0.181927	0	1
TOP3PR	322	0.064394	0.014327	0	0.113636
AGPARTPS	322	2.769231	0	2.769231	2.769231
AGLABPS	322	12.41209	0	12.41209	12.41209
DEPOTM1	322	6415171	15203060	0	1.71E+08
RFI	322	2369	0	2369	2369
ACWT	322	498	0	498	498
MTTC (HULL)	322	19.69749	23.71661	0	186.2609
MTTC (COMM)	322	12.31633	14.45076	0	104.3333
MTTC (WEAP)	322	16.47156	30.72711	0	266
NEWCAS (HULL)	322	5.565217	5.304771	0	40
NEWCAS (COMM)	322	2.391304	2.801143	0	17
NEWCAS (WEAP)	322	2.590062	3.600748	0	18

Fiscal Year 1985

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	330	70.93491	20.65191	0.54	100
POTF(FLEET)	1	63.2497	0	63.2497	63.2497
MTTC	330	19.80909	19.6194	2	226
NEWCAS	330	8.121212	6.19372	1	38
ORDREW	330	49612.3	160384.6	0	1369570
HRSUWM1	330	2513.93	1356	0	5616
LGLDPE	330	137.5485	122.4944	0	889
TSLDPE	330	369.1152	374.6165	0	2810
MOD	330	0.039394	0.194826	0	1
TOP3PR	330	0.066968	0.013954	0	0.12234
AGPARTPS	330	2.745206	0	2.745206	2.745206
AGLABPS	330	12.42192	0	12.42192	12.42192
DEPOTM1	330	6191340	19780753	0	2.47E+08
RFI	330	2693	0	2693	2693
ACWT	330	480	0	480	480
MTTC (HULL)	330	18.34556	24.97629	0	253

MTTC (COMM)	330	10.66798	15.02895	0	94.5
MTTC (WEAP)	330	10.20537	16.10917	0	147.5
NEWCAS (HULL)	330	4.70303	4.362348	0	25
NEWCAS (COMM)	330	1.787879	2.211569	0	11
NEWCAS (WEAP)	330	2.006061	2.837005	0	16

Fiscal Year 1986

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	343	75.69254	19.42376	0	99.45
POTF(FLEET)	1	68.71542	0	68.71542	68.71542
MTTC	343	17.93878	15.15955	2	121
NEWCAS	343	7.029155	5.398101	1	31
ORDREW	343	74511.09	445578.9	0	7426160
HRSUWM1	343	2238.65	1283.18	0	5354
LGLDPE	343	137.3003	111.5586	0	616
TSLDPE	343	347.3615	341.1552	0	2015
MOD	343	0.037901	0.191236	0	1
TOP3PR	343	0.071141	0.014852	0.041096	0.142857
AGPARTPS	343	2.708556	0	2.708556	2.708556
AGLABPS	343	12.23797	0	12.23797	12.23797
DEPOTM1	343	6550700	14256561	0	1.42E+08
RFI	343	3019	0	3019	3019
ACWT	343	461	0	461	461
MTTC (HULL)	343	14.88056	16.49149	0	120.5
MTTC (COMM)	343	11.0561	19.91961	0	217
MTTC (WEAP)	343	10.97526	22.77498	0	326
NEWCAS (HULL)	343	3.909621	3.652364	0	24
NEWCAS (COMM)	343	1.612245	1.900622	0	13
NEWCAS (WEAP)	343	1.778426	2.372578	0	13

Fiscal Year 1987

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	319	78.37687	17.1438	8.33	100
POTF(FLEET)	1	69.20957	0	69.20957	69.20957
MTTC	319	15.42633	11.18147	2	116
NEWCAS	319	6.758621	5.683589	1	48
ORDREW	319	37588.06	160706.1	0	1291067
HRSUWM1	319	2210.57	1121.41	0	5153
LGLDPE	319	128.3918	108.8922	1	616
TSLDPE	319	324.8715	308.8865	0	2252
MOD	319	0.056426	0.231106	0	1
TOP3PR	319	0.069794	0.014173	0.041667	0.157895
AGPARTPS	319	3.311111	0	3.311111	3.311111
AGLABPS	319	11.68611	0	11.68611	11.68611
DEPOTM1	319	5915506	17598854	0	2.67E+08
RFI	319	3363	0	3363	3363
ACWT	319	423	0	423	423
MTTC (HULL)	319	13.10727	13.05513	0	90.5

MTTC (COMM)	319	9.585535	15.17191	0	116
MTTC (WEAP)	319	8.658825	14.9191	0	189
NEWCAS (HULL)	319	3.868339	4.386396	0	44
NEWCAS (COMM)	319	1.363636	1.869835	0	12
NEWCAS (WEAP)	319	1.830721	2.404699	0	16

Fiscal Year 1988

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	331	76.82637	19.07583	1	100
POTF(FLEET)	1	68.2535	0	68.2535	68.2535
MTTC	331	19.26586	23.00781	1	212
NEWCAS	331	6.785499	5.403077	1	33
ORDREW	331	40815.36	154574.3	0	1062657
HRSUWM1	331	2246.06	1146.6	0	5520
LGLDPE	331	134.6284	132.5209	0	1079
TSLDPE	331	310.7915	309.536	0	2618
MOD	331	0.084592	0.278695	0	1
TOP3PR	331	0.064852	0.017265	0	0.15
AGPARTPS	331	3.12227	0	3.12227	3.12227
AGLABPS	331	11.58919	0	11.58919	11.58919
DEPOTM1	331	5175022	13191478	0	1.38E+08
RFI	331	3484	0	3484	3484
ACWT	331	396	0	396	396
MTTC (HULL)	331	14.9331	20.11977	0	199.5
MTTC (COMM)	331	10.66585	19.38766	0	212
MTTC (WEAP)	331	10.54036	21.08472	0	194
NEWCAS (HULL)	331	3.719033	3.628536	0	22
NEWCAS (COMM)	331	1.47432	1.902575	0	11
NEWCAS (WEAP)	331	1.779456	2.505086	0	15

Fiscal Year 1989

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	334	73.99958	20.54731	0	99.72
POTF(FLEET)	1	63.53504	0	63.53504	63.53504
MTTC	334	17.91317	15.50457	1	131
NEWCAS	334	8.254491	7.271931	1	43
ORDREW	334	29847.72	139640.4	0	1143082
HRSUWM1	334	2279.43	1131.83	0	5757
LGLDPE	334	133.5958	122.4373	0	1079
TSLDPE	334	424.2515	339.051	0	2626
MOD	334	0.161677	0.368706	0	1
TOP3PR	334	0.075554	0.017826	0.035897	0.157895
AGPARTPS	334	2.201289	0	2.201289	2.201289
AGLABPS	334	12.51911	0	12.51911	12.51911
DEPOTM1	334	5515207	14260149	0	1.24E+08
RFI	334	3210	0	3210	3210
ACWT	334	384	0	384	384
MTTC (HULL)	334	16.33759	17.70921	0	136.6875

MTTC (COMM)	334	9.325464	13.82493	0	114
MTTC (WEAP)	334	24.40714	49.71017	0	281
NEWCAS (HULL)	334	5.065868	5.112709	0	38
NEWCAS (COMM)	334	1.476048	1.978343	0	13
NEWCAS (WEAP)	334	2.068862	2.853488	0	17

Fiscal Year 1990

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	311	68.15778	23.64415	0	99.45
POTF(FLEET)	1	56.49446	0	56.49446	56.49446
MTTC	311	19.2926	16.94834	2	157
NEWCAS	311	9.305466	7.941313	1	47
ORDREW	311	26933.61	117828.8	0	640830.5
HRSUWM1	311	1989.41	1119.49	0	5165
LGLDPE	311	121.0579	111.2311	0	599
TSLDPE	311	575.9936	439.0814	0	2430
MOD	311	0.157556	0.364912	0	1
TOP3PR	311	0.071024	0.017162	0	0.1129
AGPARTPS	311	2.104643	0	2.104643	2.104643
AGLABPS	311	12.69153	0	12.69153	12.69153
DEPOTM1	311	5197223	11288776	0	1.23E+08
RFI	311	3018	0	3018	3018
ACWT	311	346	0	346	346
MTTC (HULL)	311	17.90961	18.24033	0	163.5
MTTC (COMM)	311	8.45761	11.8109	0	83
MTTC (WEAP)	311	13.91035	25.23062	0	230
NEWCAS (HULL)	311	5.726688	5.528743	0	32
NEWCAS (COMM)	311	1.665595	2.100094	0	12
NEWCAS (WEAP)	311	2.215434	2.894135	0	16

Fiscal Year 1991

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	286	69.51962	22.02502	1	100
POTF(FLEET)	1	55.60256	0	55.60256	55.60256
MTTC	286	19.74126	17.70924	2	178
NEWCAS	286	8.727273	7.271364	1	45
ORDREW	286	33633.96	160551.5	0	1395008
HRSUWM1	286	2342.04	1040.23	0	4815
LGLDPE	286	107.1399	100.1553	0	599
TSLDPE	286	790.8497	521.5254	0	2795
MOD	286	0	0	0	0
TOP3PR	286	0.071377	0.016274	0	0.2
AGPARTPS	286	2.294965	0	2.294965	2.294965
AGLABPS	286	13.5406	0	13.5406	13.5406
DEPOTM1	286	4146694	6877915	0	63178563
RFI	286	3372	0	3372	3372
ACWT	286	293	0	293	293
MTTC (HULL)	286	18.55831	21.75421	0	190

MTTC (COMM)	286	10.53764	16.43501	0	114
MTTC (WEAP)	286	11.59086	19.80243	0	168
NEWCAS (HULL)	286	5.678322	5.588336	0	40
NEWCAS (COMM)	286	1.416084	1.87269	0	11
NEWCAS (WEAP)	286	1.937063	2.681233	0	17

Fiscal Year 1992

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
POTF	263	74.80502	19.88655	10.94	100
POTF(FLEET)	1	57.5396	0	57.5396	57.5396
MTTC	263	15.93156	12.17976	1	82
NEWCAS	263	7.711027	6.361873	1	35
ORDREW	263	36817.18	216063.7	0	2583994
HRSUWM1	263	2593.38	1281.18	0	5245
LGLDPE	263	121.5856	118.6838	0	1096
TSLDPE	263	880.4106	682.2013	0	2599
MOD	263	0.019011	0.136825	0	1
TOP3PR	263	0.064134	0.023223	0	0.098434
AGPARTPS	263	2.498707	0	2.498707	2.498707
AGLABPS	263	15.5773	0	15.5773	15.5773
DEPOTM1	263	4772068	8880841	0	71875816
RFI	263	3136	0	3136	3136
ACWT	263	284	0	284	284
MTTC (HULL)	263	14.48544	12.47885	0	76
MTTC (COMM)	263	8.553401	15.88424	0	116
MTTC (WEAP)	263	11.7418	26.88212	0	363
NEWCAS (HULL)	263	5.631179	5.166401	0	34
NEWCAS (COMM)	263	1.1673	1.737154	0	10
NEWCAS (WEAP)	263	1.539924	2.195876	0	12

APPENDIX H. ANNUAL MEAN RELATIVE ERRORS FOR SRM

Appendix H contains the annual values of MRE for each dependent variable along with the overall POTF, MTTC, and NEWCAS variables as determined by the SRM. Note that the POTF value is unweighted for ship operating tempo, since $POTF_{FLEET}$ MRE is zero on an annual basis. The variable names should be self-explanatory.

Fiscal Year 1982

Variable	*Mean*
MREPOTF	1.283076
MREMTTC	0.838617
MRENCAS	1.265576
MREMTTCH	1.11362
MREMTTCC	0.884565
MREMTTCW	0.833573
MRENHULL	1.149954
MRENCOMM	0.729752
MRENWEAP	0.77873

Fiscal Year 1983

Variable	*Mean*
MREPOTF	1.377426
MREMTTC	0.712174
MRENCAS	0.96551
MREMTTCH	1.035701
MREMTTCC	0.926618
MREMTTCW	0.744802
MRENHULL	0.968672
MRENCOMM	0.583536
MRENWEAP	0.744231

Fiscal Year 1984

Variable	*Mean*
MREPOTF	0.732977
MREMTTC	0.666643
MRENCAS	0.968828
MREMTTCH	0.993921
MREMTTCC	0.789516
MREMTTCW	0.664708
MRENHULL	0.956415
MRENCOMM	0.544243
MRENWEAP	0.590913

Fiscal Year 1985

Variable	*Mean*
MREPOTF	0.915977
MREMTTC	0.606102
MRENCAS	0.961536
MREMTTCH	0.844416

MREMTTCC	0.910603
MREMTTCW	0.892355
MRENHULL	0.991378
MRENCOMM	0.528665
MRENWEAP	0.740912

Fiscal Year 1986

Variable	*Mean*
MREPOTF	0.299613
MREMTTC	0.770645
MRENCAS	1.226352
MREMTTCH	1.194388
MREMTTCC	0.891315
MREMTTCW	0.920524
MRENHULL	1.06019
MRENCOMM	0.541842
MRENWEAP	0.64708

Fiscal Year 1987

Variable	*Mean*
MREPOTF	0.216468
MREMTTC	0.589081
MRENCAS	1.174965
MREMTTCH	0.983057
MREMTTCC	0.880307
MREMTTCW	0.604962
MRENHULL	0.860357
MRENCOMM	0.607351
MRENWEAP	0.679881

Fiscal Year 1988

Variable	*Mean*
MREPOTF	0.51326
MREMTTC	0.81748
MRENCAS	1.353956
MREMTTCH	1.231326
MREMTTCC	0.978425
MREMTTCW	0.895711
MRENHULL	0.894578
MRENCOMM	0.601306
MRENWEAP	0.794732

Fiscal Year 1989

Variable	*Mean*
MREPOTF	0.266183
MREMTTC	0.972135
MRENCAS	1.447639
MREMTTCH	1.478188
MREMTTCC	0.931462
MREMTTCW	1.115144
MRENHULL	1.145368

MRENCOMM	0.709774
MRENWEAP	0.773743

Fiscal Year 1990

Variable	*Mean*
MREPOTF	1.580783
MREMTTC	0.689228
MRENCAS	1.636927
MREMTTCH	0.99533
MREMTTCC	1.090451
MREMTTCW	0.958359
MRENHULL	1.316573
MRENCOMM	0.644078
MRENWEAP	0.827741

Fiscal Year 1991

Variable	*Mean*
MREPOTF	0.808719
MREMTTC	0.653805
MRENCAS	1.109934
MREMTTCH	0.909963
MREMTTCC	0.792382
MREMTTCW	0.934629
MRENHULL	1.08136
MRENCOMM	0.519077
MRENWEAP	0.641244

Fiscal Year 1992

Variable	*Mean*
MREPOTF	0.32613
MREMTTC	0.59679
MRENCAS	0.821207
MREMTTCH	0.742774
MREMTTCC	0.709327
MREMTTCW	0.649294
MRENHULL	0.798583
MRENCOMM	0.543079
MRENWEAP	0.5342

APPENDIX I. ANNUAL MEAN RELATIVE ERRORS FOR SIM

Appendix I contains the annual values of MRE for each dependent variable along with the overall POTF, MTTC, and NEWCAS variables as determined by the SIM. Note that the POTF value is unweighted for ship operating tempo, since $POTF_{FLEET}$ MRE is zero on an annual basis. The variable names should be self-explanatory.

Fiscal Year 1982

Variable	*Mean*
MREPOTF	1.238103
MREMTTC	0.785988
MRENCAS	1.466571
MREMTTCH	1.073591
MREMTTCC	1.038373
MREMTTCW	1.002055
MRENHULL	1.14992
MRENCOMM	0.886929
MRENWEAP	0.75803

Fiscal Year 1983

Variable	*Mean*
MREPOTF	1.294295
MREMTTC	0.735247
MRENCAS	1.173121
MREMTTCH	1.186773
MREMTTCC	1.037776
MREMTTCW	0.731419
MRENHULL	1.08895
MRENCOMM	0.622473
MRENWEAP	0.767484

Fiscal Year 1984

Variable	*Mean*
MREPOTF	0.690753
MREMTTC	0.687423
MRENCAS	1.188086
MREMTTCH	1.200254
MREMTTCC	0.870102
MREMTTCW	0.603969
MRENHULL	1.088357
MRENCOMM	0.569591
MRENWEAP	0.619544

Fiscal Year 1985

Variable	*Mean*
MREPOTF	0.944841
MREMTTC	0.604474
MRENCAS	1.147621
MREMTTCH	0.913403

MREMTTCC	0.868561
MREMTTCW	0.850655
MRENHULL	1.012964
MRENCOMM	0.573692
MRENWEAP	0.777441

Fiscal Year 1986

Variable	*Mean*
MREPOTF	0.311246
MREMTTC	0.700814
MRENCAS	1.333624
MREMTTCH	1.12517
MREMTTCC	0.808132
MREMTTCW	1.032299
MRENHULL	1.027521
MRENCOMM	0.557082
MRENWEAP	0.671739

Fiscal Year 1987

Variable	*Mean*
MREPOTF	0.226506
MREMTTC	0.55664
MRENCAS	1.061272
MREMTTCH	0.994422
MREMTTCC	0.847893
MREMTTCW	0.565151
MRENHULL	0.727044
MRENCOMM	0.495361
MRENWEAP	0.637733

Fiscal Year 1988

Variable	*Mean*
MREPOTF	0.578239
MREMTTC	0.738457
MRENCAS	1.127977
MREMTTCH	1.14046
MREMTTCC	0.823834
MREMTTCW	0.906828
MRENHULL	0.703789
MRENCOMM	0.458277
MRENWEAP	0.679027

Fiscal Year 1989

Variable	*Mean*
MREPOTF	0.274753
MREMTTC	0.839525
MRENCAS	1.226905
MREMTTCH	1.190338
MREMTTCC	0.77154
MREMTTCW	1.331093
MRENHULL	0.910915

MRENCOMM	0.531155
MRENWEAP	0.676606

Fiscal Year 1990

Variable	*Mean*
MREPOTF	1.935643
MREMTTC	0.657738
MRENCAS	1.272971
MREMTTCH	0.804964
MREMTTCC	0.888167
MREMTTCW	1.202651
MRENHULL	1.034911
MRENCOMM	0.449412
MRENWEAP	0.662251

Fiscal Year 1991

Variable	*Mean*
MREPOTF	0.898137
MREMTTC	0.595453
MRENCAS	0.903682
MREMTTCH	0.823838
MREMTTCC	0.66558
MREMTTCW	1.053664
MRENHULL	0.870478
MRENCOMM	0.478186
MRENWEAP	0.556347

Fiscal Year 1992

Variable	*Mean*
MREPOTF	0.357461
MREMTTC	0.743299
MRENCAS	0.872892
MREMTTCH	1.031032
MREMTTCC	0.660948
MREMTTCW	0.71774
MRENHULL	0.871769
MRENCOMM	0.57976
MRENWEAP	0.528589

APPENDIX J. CODE USED FOR JACKKNIFE OF THE SRM

Appendix J contains the code used for jackknife of the SRM. It only contains code that is different from Appendix A. Where the comment [*Same code as in Appendix A*] appears, the code for the jackknife is identical to the code in Appendix A. This code is only one of six that was used to produce the 120 iterations. The remaining five programs were identical except that each began the macro's "do" loop in increments of ten higher. Additionally, the "OUT" data sets at the end of the remaining five programs use the applicable higher numbers.

```
//SRM6Z1A JOB CLASS=J,USER=S6402
//*MAIN LINES=(99)
// EXEC SAS
//WORK DD UNIT=SYSDA,SPACE=(CYL,(100,5))
//PDAT DD UNIT=SYSDA,DISP=SHR,DSN=MSS.S6402.FY92.POTF
//REG2 DD DISP=SHR,DSN=MSS.S6402.MATHTECH
//NEWDAT DD DISP=(NEW,CATLG),UNIT=SYSDA,
// SPACE=(TRK,(260,1),RLSE),
// DSN=MSS.S6402.FY92.FMDB.LAG2
//RESLTZ DD DISP=(OLD,KEEP),UNIT=SYSDA,
// SPACE=(TRK,(10,10),RLSE),
// DSN=MSS.S6402.FY92.RESULTS2
//SYSIN DD *

OPTIONS LS=132;
 DATA R2;
 SET REG2.MASTER92;
```

[*Same code as in Appendix A*]

```
 %MACRO JACKER;
 %DO I=79 %TO 3404 %BY 175;

 DATA ONE; SET R2;
 IF _N_ GE &I AND _N_ LE (&I+9) THEN DO; MTTCH=.; MTTCW=.; MTTCC=.;
 NEWHULL=.;  NEWCOMM=.; NEWWEAP=.; END;

 /* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
   FACTOR .001 */
 PROC NLIN METHOD = DUD MAXITER = 50 G4  /* MTTC HULL */
 CONVERGE = .001 DATA=ONE EFORMAT;
```

[*Same code as in Appendix A*]

```
 /* CREATE AND SORT THE SET MTTCW */
 DATA MTTCW;
 SET RESLTZ.MTTCW;
 KEEP TYPE HULL YEAR PMTTCW MTTCW;
```

```
PROC SORT; BY TYPE HULL YEAR;

DATA PD; SET PD;
PROC SUMMARY NWAY; VAR NOPDAY; CLASS YEAR;
OUTPUT OUT=OPDAYS SUM=TOTALOP;

/* CREATE A SAS DATA SET NAMED 'WHOLE' CONSISTING OF THE VARIABLES
  LISTED IN THE MERGE AND SORTED BY TYPE,HULL,YEAR  */
DATA WHOLE;
MERGE NHULL NCOMM NWEAP MTTCH MTTCC MTTCW PD;
BY TYPE HULL YEAR;
IF PMTTCW=. THEN DELETE;
IF PMTTCH=. THEN DELETE;
IF PMTTCC=. THEN DELETE;

PROC SORT; BY YEAR;
DATA WHOLE; MERGE OPDAYS WHOLE; BY YEAR;

/* CALCULATE THE FOLLOWING FOUR VARIABLES */
NEWCAS = NEWCOMM + NEWHULL + NEWWEAP;
MTTC = (NEWHULL/NEWCAS)*MTTCH + (NEWWEAP/NEWCAS)*MTTCW +
   (NEWCOMM/NEWCAS)*MTTCC;
PNEWCAS = PNHULL + PNCOMM + PNWEAP;
PMTTC = (PNHULL/PNEWCAS)*PMTTCH + (PNWEAP/PNEWCAS)*PMTTCW +
   (PNCOMM/PNEWCAS)*PMTTCC;
POTF = EXP(-.0024*
(PNHULL*PMTTCH+PNCOMM*PMTTCC+PNWEAP*PMTTCW));
DF = POTF * NOPDAY;
POTF = DF / TOTALOP;
PROC SORT; BY YEAR;

PROC SUMMARY; VAR POTF; CLASS YEAR;
OUTPUT OUT=TOTPOTF SUM=PPOTF;
DATA WHOLE; MERGE TOTPOTF WHOLE; BY YEAR;

PROC SUMMARY; VAR POTF PPOTF MTTC PMTTC NEWCAS PNEWCAS;
CLASS YEAR;
OUTPUT OUT=OUT&I MEAN=;
PROC PRINT;

%END; %MEND JACKER; %JACKER RUN;

DATA ALL; SET OUT79 OUT254
OUT429 OUT604 OUT779 OUT954 OUT1129
OUT1304 OUT1479 OUT1654 OUT1829 OUT2004 OUT2179 OUT2354 OUT2529
OUT2704 OUT2879 OUT3054 OUT3229 OUT3404;
PROC SORT; BY YEAR;
PROC PRINT;
PROC UNIVARIATE PLOT NORMAL;
VAR POTF PPOTF MTTC PMTTC NEWCAS PNEWCAS;
BY YEAR;
```

APPENDIX K. CODE USED FOR JACKKNIFE OF THE SIM

Appendix K contains the code used for jackknife of the SIM. It only contains code that is different from Appendix B. Where the comment [*Same code as in Appendix B*] appears, the code for the jackknife is identical to the code in Appendix B. This code is only one of six that was used to produce the 120 iterations. The remaining five programs were identical except that each began the macro's "do" loop in increments of ten higher. Additionally, the "OUT" data sets at the end of the remaining five programs use the applicable higher numbers.

```
//SIM6Z1  JOB CLASS=J,USER=S6402
//*MAIN LINES=(99)
// EXEC SAS
//WORK DD UNIT=SYSDA,SPACE=(CYL,(10,10))
//PDAT DD UNIT=SYSDA,DISP=SHR,DSN=MSS.S6402.FY92.POTF
//REG2 DD DISP=SHR,DSN=MSS.S6402.MATHTECH
//RESLTZ DD DSN=MSS.S6402.FY91.MODEL.PREDACT1,
// DISP=(OLD,KEEP),UNIT=SYSDA,
// SPACE=(TRK,(10,10),RLSE)
//SYSIN DD *

OPTIONS LS=132;
 DATA STOCKF1;
 INPUT YEAR ACWT RFIT OPNDEF;
```

[*Same code as in Appendix B*]

```
 %MACRO JACKER;
 %DO I=79  %TO 3404 %BY 175 ;

 DATA ONE; SET R2 ;
 IF _N_ GE &I AND _N_ LE (&I+9) THEN DO ;
    MTTCH=.; MTTCW=.; MTTCC=.; NEWHULL=.; NEWCOMM=.; NEWWEAP=.;
 END;

 /* PERFORM NONLINEAR REGRESSION WITH MAX ITERATIONS 50 AND CONVERGENCE
   FACTOR .001 */
 PROC NLIN METHOD = DUD MAXITER = 50 G4   /* MTTC HULL */
 CONVERGE = .001 DATA=ONE EFORMAT;
```

[*Same code as in Appendix B*]

```
 DATA MTTCW;
 SET RESLTZ.MTTCW;
 KEEP TYPE HULL YEAR PMTTCW MTTCW;
```

```
PROC SORT; BY TYPE HULL YEAR;

DATA PD ; SET PD ;
PROC SUMMARY NWAY ; VAR NOPDAY ; CLASS YEAR ;
OUTPUT OUT=OPDAYS SUM=TOTALOP ;

DATA WHOLE;
MERGE NHULL NCOMM NWEAP MTTCH MTTCC MTTCW PD;
BY TYPE HULL YEAR;
IF PMTTCW=. THEN DELETE;
IF PMTTCH=. THEN DELETE;
IF PMTTCC=. THEN DELETE;

PROC SORT ; BY YEAR ;
DATA WHOLE ; MERGE OPDAYS WHOLE ; BY YEAR ;

NEWCAS = NEWCOMM + NEWHULL + NEWWEAP;
MTTC = (NEWHULL/NEWCAS)*MTTCH + (NEWWEAP/NEWCAS)*MTTCW +
   (NEWCOMM/NEWCAS)*MTTCC;
PNEWCAS = PNCOMM + PNHULL + PNWEAP;
PMTTC = (PNHULL/PNEWCAS)*PMTTCH + (PNWEAP/PNEWCAS)*PMTTCW +
   (PNCOMM/PNEWCAS)*PMTTCC;
POTF = EXP(-.0024*
(PNHULL*PMTTCH+PNCOMM*PMTTCC+PNWEAP*PMTTCW));
DF = POTF * NOPDAY;
POTF = DF / TOTALOP ;
PROC SORT ; BY YEAR ;

PROC SUMMARY; VAR POTF;
CLASS YEAR;
OUTPUT OUT=TOTPOTF SUM=PPOTF ;
DATA WHOLE ; MERGE TOTPOTF WHOLE ; BY YEAR ;

PROC SUMMARY; VAR POTF PPOTF MTTC PMTTC NEWCAS PNEWCAS;
CLASS YEAR;
OUTPUT OUT=OUT&I MEAN=;
PROC PRINT;

%END; %MEND JACKER; %JACKER RUN;

DATA ALL; SET OUT79 OUT254
OUT429 OUT604 OUT779 OUT954 OUT1129
OUT1304 OUT1479 OUT1654 OUT1829 OUT2004 OUT2179 OUT2354 OUT2529
OUT2704 OUT2879 OUT3054 OUT3229 OUT3404;
PROC SORT; BY YEAR;
PROC PRINT;
PROC UNIVARIATE PLOT NORMAL;
VAR POTF PPOTF MTTC PMTTC NEWCAS PNEWCAS;
BY YEAR;
```

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